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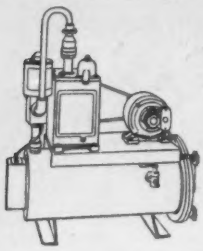

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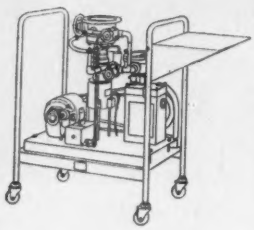

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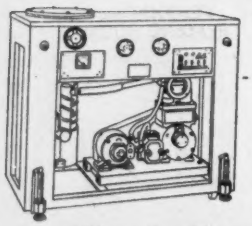

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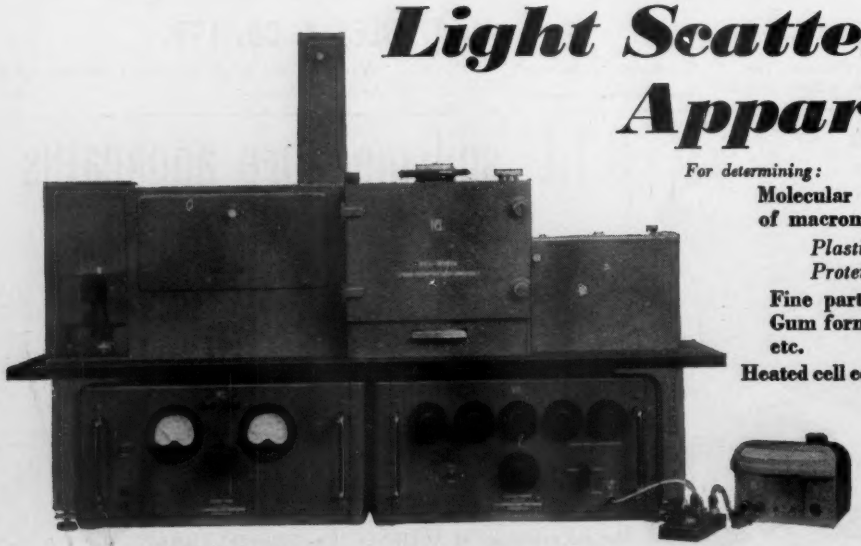

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APPRENTICESHIP AND TECHNICAL EDUCATION

THE Sub-Committee of the National Joint Advisory Council, appointed in the spring of 1956, with Mr. Robert Carr as chairman, has now issued a report* on recruitment and training of young workers in industry which has been awaited with some eagerness. Its terms of reference, "To consider the arrangements for the training of young workers in industry, with particular reference to the adequacy of intake into apprenticeship and other forms of training, in the light of the expected increase in the number of young persons entering employment and the need to ensure an adequate supply of trained workers for future needs", suggested that it would throw some light on the numerical requirements of industry. This in turn would facilitate a more accurate assessment of the balance between technical and technological education in Britain, and even of university education also. Without information at the craftsman- and technician-level corresponding to the report on requirements for scientific and engineering man-power issued in the autumn of 1956, it is impossible to judge whether the expansion of technical and technological education is being planned on sound lines and what, if any, adjustments are needed to ensure that the scientist and technologist are provided with a sufficiency of supporting technicians and craftsmen to avoid waste of highly trained man-power and expensive equipment.

Nor is this all. University expansion in Britain to-day has to be planned, not simply to ensure a continuing supply of first-rate administrators and research workers—in science, technology and other fields; to an increasing extent it must be concerned with the production of ordinary pass-degree men who will find their place as sales or production managers, commercial travellers, primary or secondary school teachers and middle-grade technicians of varied types, as well as the customary comparatively limited number of honours graduates. Technical and university education is now concerned with the bulk of the nation, for in the future some 60 per cent or more of the young men and women of Britain must be given the best scientific and technical training we can desire or they can receive. So far as the universities are concerned, they must ensure that the new generation is at least as well educated as its counterpart in the United States. It means that we must see that the greater part of the youth of the country is now given every opportunity and encouragement to continue its non-scientific education and to develop non-scientific interests and gifts in the vital ten years between sixteen and twenty-six.

The subject of the Carr report ought to be considered in this context. The balance between technical and technological and university education should be determined broadly in accordance with the numbers of school-leavers which are expected to flow by the various routes into industrial, commercial, professional and other spheres of national life. Nor is it simply a matter of seeing that the educational institutions are appropriate in size and equipment, and that they are properly distributed and effectively staffed. We should be concerned also to see that the needs and opportunities are attractively and fairly put before the school-leaver, that obstacles that might hinder him entering on the chosen career are minimized, and that at no stage in his training or employment is there frustration or waste. Especially we should see that the basic education given, and also the subsequent technical training, are such as to develop the flexibility and broad outlook that an age of rapid technical change demands of its workers —and indeed of all its citizens.

The immediate occasion of the Carr inquiry was the forthcoming increase in the number of school-leavers; but although the Committee begins with an analysis of the 'bulge', as it is called, and admits that a re-examination of our training arrangements is required, the report throws no light on industry's quantitative requirements. It points out that, for the peak year 1962, the number of school-leavers aged fifteen upwards will reach 701,000—a 50 per cent increase on 1956: for 1964, school-leavers of seventeen will exceed those of 1956 by 106 per cent, and for 1965 those of eighteen or more will exceed those of 1956 by 109 per cent. Again, in 1962, national service is due to end, and during the following five years between 200,000 and 250,000 young men will become available for civilian employment, and consequently in the early 1960's the number of ex-apprentices becoming available for employment will increase.

Viewed against the expected increase of 1,500,000 in the working population of Great Britain over the next twenty-five years, this increase in skilled man-power, in so far as industry is not at present recruiting sufficient apprentices to meet its future needs, will do no more than help to remedy that inadequate intake. Here, however, there is the question of finding instructors for the larger number of apprentices, while the disappearance of national service may encourage more firms to take them on. Lady Gertrude Williams has shown how large a proportion of industry at present employs no apprentices. Of the general engineering firms covered by her inquiry, half of those employing less than 100 workers (representing 19 per cent of the total employed in the industry) and one-fifth of the firms employing between 100 and 500 workers had no apprentices. Similarly, half the electrical engineering firms employing 100–500 workers and half the iron and steel firms with less than 500 workers employed no apprentices.

* Training for Skill: Recruitment and Training of Young Workers in Industry—Report by a Sub-Committee of the National Joint Advisory Council. Pp. vi+36. (London: H.M. Stationery Office, 1958.) 2s. 6d. net.

The Carr Committee rightly points out that we should not allow the opportunities of the increased numbers of young people for obtaining skilled employment to be adversely affected because they happened to be born at a particular time. Moreover, they represent an additional supply of potential skill which must not be allowed to go to waste, for it will do no more than reduce the decline in the relative size of Britain's labour force compared with the total population, unless there is a change in customary ages of retirement. In twenty-five years time, there will be about 9,500,000 people of pensionable age compared with about 7,000,000 to-day.

As to numbers of craft apprentices, the Carr Committee admits that there are signs that the present intake is inadequate; although it recommends that the intake of each industry should be sufficiently high to enable it to take full advantage of the bulge. It regards the problem as one of training, not of employment; nor does it even recommend the compilation of better statistics than we at present possess. It is content to leave this to the individual industries, suggesting that appropriate bodies in each industry should assess the number of apprentices needed during the next few years. While the report considers it essential that industries lose no time in collecting information about wastage-rates, it is suggested that, having determined the ratio of apprentices to skilled workers required, each industry should consider how its requirements are to be met: whether, for example, each firm should train its appropriate allocation of apprentices, or whether training should be concentrated in those firms best equipped to give it.

The Carr Committee makes one specific recommendation here. It suggests the establishment of a national apprenticeship council, with advisory but not executive powers, with the specific function of keeping apprenticeship and training arrangements in general under review; this would, *inter alia*, collect and disseminate information about those aspects of training which are common to more than one industry, including the detailed study of practice in other countries which might reveal many points of use to British industries. Such a council, it thinks, should be established by industry.

The report is no less disappointing from the point of view of actual training. The Committee professes itself to be satisfied that the traditional apprenticeship system should form the foundation of future training arrangements, though it admits that some practices need re-examination. Since, however, it admits also that more flexibility is required in the maximum age of entry into apprenticeship, that methods of training could be improved, and that individuals should be equipped to meet technical change by training for a wider range of skill than has often been customary, the conclusion that "the apprenticeship system must not be allowed to lose its capacity for change and improvement" is perhaps a consequence of the composition of the Committee itself.

No other interpretation seems possible in view of Lady Gertrude Williams's recent searching inquiry. There is little awareness in the Carr report of the danger that the expansion of scientific and technological education may be frustrated of its effect in part by lack of sufficient adequately trained craftsmen and auxiliaries. For all its inquiry into practice in the United States, Australia and France, and its visit to Western Germany, the Committee seems too content to believe that the apprenticeship system has continuously adjusted itself to meet changing circumstances and industrial requirements to ask whether better results could be attained more easily and economically by methods other than the schemes of training adopted by most large firms in Britain. It seems satisfied that industry should carry on and expand the traditional ways of apprenticeship, without much consideration whether a system dating, not from the nineteenth but from the twelfth century and designed for an entirely different social setting, is necessarily the best that could be devised.

There is not in this report any attempt at a detached and scientific examination of methods of selection or of the kind of training needed to ensure that young people going into skilled industry should be properly prepared for their work. Such an examination is an essential preliminary to the wise planning of technical co-operation, and to the effective co-operation between industry and the technical colleges. Its absence from this report, even the recognition of its necessity, substantiates Lady Williams's assertion that the modern acceptance of apprenticeship is not based on any examination of its merits as a method of training skilled men.

The Carr Committee does indeed believe that it is time for a fresh look at some existing apprenticeship practices and recognizes that far-reaching changes are taking place in the educational system of Britain. Only by implication does it admit, however, that the changes in the modern social and educational system are disregarded, and it fails to emphasize that, unlike his predecessor, the modern apprentice has had the opportunity to acquire a general education up to fifteen and thus to grasp with greater ease some of the scientific principles upon which skilled processes are based. Further, although it recommends that there should be opportunities for the capable young trainee to obtain promotion, either to more skilled or responsible employment, or for further training, it does not challenge the inherent assumption of the present system that a boy who has spent the prescribed time in the shops will reach the necessary standard of competence. It rejects, in fact, the passing of a test being made a condition for the completion of apprenticeship, though it concludes that a test which confers an additional qualification on an ex-apprentice has proved of value.

Nevertheless, the Carr report displays between the lines what Lady Williams has challenged outright—the satisfaction of the trade unions with the present system so long as industry will employ those who have passed the prescribed time in the shops, and no other, and their inflexible insistence that apprenticeship must end at twenty-one and last five years. It is this inflexibility that is inconsistent with the educational and industrial context of to-day, and

even the Carr Committee urges that those who stay longer at school should be allowed to enter apprenticeship at a later age and obtain a remission of the apprenticeship period. Young people who make a wrong initial choice of employment should not, it is urged, be further debarred from entering an apprenticeship because they are above the normal age.

Nor is this the only point at which such inflexibility is anti-social. If a skilled trade must be entered at sixteen years of age and qualification acquired at twenty-one or not at all, there will be waste as well as loss of talent. The assumption that all skilled trades take five years to acquire needs challenging from the point of view of the instructor as well as that of the varying ability of the apprentice. Lady Williams has done good service by directing attention to the fundamental questions which should be examined before the relation between industry and the technical colleges in this field can be determined. Practical instruction is not, and should not be, the primary function of the technical college, any more than good craftsmen are necessarily good teachers. Great Britain is the only big industrial country which gives so little attention to training skilled men. Nowhere else is the period of apprenticeship so long and inflexible from the point of view of age, and in other major industrial countries workers can only claim the adult skilled rate on proof of competence by passing an appropriate test.

It could scarcely have been expected that a committee on which employers and the Trades Union Congress were equally represented would have had the courage and independence to make the recommendations to which Lady Williams's inquiry led her. It does well, indeed, in recommending the scrapping of the age restriction on apprenticeship; but there is no indication that either employers or trade unions are yet prepared to recognize the existence of different degrees of intellectual ability and manual skill. Nevertheless, these are the first two steps to be taken if the apprenticeship system in Britain is to be brought into line with modern social and industrial needs. The steps required to provide a hierarchy of talent and to bring training methods up to date require further inquiry; but without such flexibility, we are unlikely either to make efficient use of our existing trained man-power at the various levels or to expand particular categories as may be needed.

What the Carr report should do is stimulate further discussion on the crucial issues that Lady Williams has emphasized. Such discussion is badly needed, as a recent debate in the House of Commons on the recruitment and training of teachers illustrates. The expansion of the apprenticeship system is clearly linked with the availability of teachers and instructors in Britain; but although reference was made in the debate to the high proportion of skilled man-power in the Forces and its potential value as a source of technical teachers was recognized, no reference was made to the implications for the apprenticeship system. Neither as a source of instructors nor as a challenge to the rigidity of the age structure of the apprenticeship system and entry to skilled trades was the bearing of all this on Britain's needs for skilled man-power and her economic and industrial strength even noted. If the Carr report, for all its shortcomings, still directs attention to the searching questions which Lady Gertrude Williams has asked and stimulates the further inquiry, frank discussion and uninhibited and constructive thinking that are needed, it will nevertheless have deserved well of the nation. As Mr. A. G. Korol has emphasized in his recent book on Soviet education, the initial task is to see that our educational system is adequate to its expanding goals and responsibilities in scale, character, flexibility, vigour and quality. It is by such tests that any particular part of it such as apprenticeship is to be judged, not indeed in isolation, but as part of a whole system. Only by such means can the real cost of apprenticeship be judged, and a true assessment obtained of the changes necessary to make it adequate to the new world of rapid technological change, and Britain's present—and not her past—economy.

PHOSPHOROFLUORIDATES AND FLUOROACETATES

Some Aspects of the Chemistry and Toxic Action of Organic Compounds containing Phosphorus and Fluorine

By Dr. Bernard Charles Saunders. Pp. xvi+231. (Cambridge: At the University Press, 1957.) 32*s*. 6*d*. net.

THIS monograph by Dr. B. C. Saunders deals with certain compounds of phosphorus and fluorine. He makes it clear that it arose as the result of lectures given in Holland. This explains why the emphasis is upon special features with which the author has had personal experience rather than an attempt to make it completely exhaustive. Nevertheless, it does contain, in addition to a very good account of the fields in which he has worked with colleagues since 1939, much of the general literature of the subject. As the book is written primarily for chemists, the author has added a readable account of the applications to physiology and where necessary anatomical details of the nervous system, a necessary addition because the compounds of most importance are those with a toxic action. The two classes of compounds mainly dealt with are the phosphorofluoridates which we used to call fluorophosphonates, and the 'fluoroacetates', among which can be included the group as a whole of compounds containing the F–CH_2 group.

After a general introduction on the scope of the book to put the reader on his feet, Dr. Saunders deals in detail with the preparation of the esters of phosphorofluoridate, especially di-*iso*propyl phosphorofluoridate, and then in general with the pharmacology of the action of the anticholinesterase compounds. He also refers to the preparation of radioactive compounds in the series. There is next given an account of preparation of the esters of phosphoric acid and also of some of the German work initiated by Schrader and not known until after the War; among these compounds were the German war nerve gases Sarin and Tabun.

Turning to the fluoroacetates, initiated by Swarts (1896), he describes the preparation and details of the

improvements in making F–C compounds and of a large number of new compounds made with colleagues, especially Pattison. Their discoveries led to the realization that there was an alternation of toxicity in compounds containing FCH_2; and even-numbered ω-fluorofatty acids were toxic and those with an odd number of carbon atoms much less toxic. This fact has been most useful in developing further the biochemistry of this group of compounds. An authoritative and readable account is given of the synthesis of several of these fluoro compounds. It is particularly interesting that Marais found in South Africa, in 1943, that the toxic principle of the plant *Dichapetalum cymosum* (gifblaar) was fluoroacetic acid. It is a well-known plant toxic to cattle. The author also includes an account of more recent biochemical work in which it has been shown that $F–C_2$ compounds under certain conditions undergo a 'lethal synthesis' *in vivo* to fluorocitrate, which then blocks the tricarboxylic acid cycle at the citrate stage.

The book finishes with an account of some more modern systemic insecticides, among which may be mentioned OMPA (octamethylpyrophosphoramide), systox and parathion; this makes the book more complete.

For the benefit of those who may not be familiar with methods of analysis in this field, the author has included the methods of estimating fluoride. Many readers will also welcome an account of the present system of naming the phosphorus compounds which has been internationally agreed.

There is an error which may mislead; on page 143, 30 mgm. should be 30 μgm.

The author deserves especial praise for his presentation of the chemistry as well as the pharmacological background, and for bringing together for the first time much of the scattered literature which was to be found previously only in various reports.

The book may be recommended as a readable and authoritative account in this field to those who are working in it as well as to those who wish to take an interest.

RUDOLPH A. PETERS

RETROSPECT ON EVOLUTION

A Hundred Years of Evolution

By Dr. G. S. Carter. Pp. x+206. (London: Sidgwick and Jackson, Ltd., 1957.) 21*s*. net.

THE mechanisms which govern evolutionary processes are of such interest to biologists that a new discussion of the problem is rarely unwelcome. Dr. G. S. Carter's estimation of the significance of Darwin's contribution to the subject, coming almost exactly one hundred years after its first publication, is fitting to the occasion by the orthodoxy of its neo-Darwinian statement.

Part 1 of the book, comprising seven chapters, is devoted to an assessment of Darwin's postulates against the climate of his time and of their impact upon zoologists and upon society. It contains little that is new but is none the less valuable as an analysis of the manner in which new ideas have grown from small and uncertain beginnings to come to sudden fruition at the hands of an individual who, by his brilliant synthesis and addition, gave substance to such gropings after the truth. The later chapters provide an analysis of the intermarriage of Darwinism, Weismannism and Mendelism which has provided us with the neo-Darwinian concept. Limited as this statement frankly is to this particular theory of evolution, it is admirable in its lucidity and in its adherence to fundamentals to the exclusion of discussion of the many genetic and selectionist bypaths along which the student of to-day is liable to be led astray. The portrayal of micro-evolution through the action of selective forces upon the deme structure of populations is compelling and satisfying as a logical discussion of most of the known data. One's doubts arise in relation to the underlying premises. It is fundamental to the neo-Darwinian theory that Weismann's concept of the inviolability of germ plasm by soma is correct, and that mutational changes in the gene complex arise solely at random; Dr. Carter (p. 87) accepts Weismann's doctrine as "undeniable when once pointed out". It is arguable, however, that the "separateness of the gonad from the rest of the soma" is a philosophical concept of the same order as that of the soul and the body. As such it may have been valid in the state of biological knowledge in Weismann's time, but it has to-day become undermined to the point of collapse by the work of endocrinologists, experimental embryologists, physiologists and cytologists, and it now provides very dubious foundations for the neo-Darwinian argument. That mutation is random is purely theoretical, depending in the first place on the validity of the divorce between germ plasm and soma, and in the second upon the absence of evidence to the contrary. Dr. Carter is well aware of the necessity to elucidate the nature of mutation but complacent that when this is achieved it will provide further support for the neo-Darwinian view. Since it would be inappropriate here to argue an opposing view, it shall suffice to remark that another interpretation is conceivable.

On "the larger course of evolution", the origins of higher taxonomic categories, as contrasted with the minute adaptations within species known collectively as micro-evolution, it is interesting to note in passing that the author is by no means convinced of the rarity of sympatric speciation. His discussion of the major problem, however, seems notably lacking in breadth and clarity when compared with the earlier chapters. It would appear that the whole course of the evolution of the extreme diversity of the animal kingdom is attributable to the micro-evolutionary adaptation and selection which have been depicted. The reader is given little hint that evolutionists have found the greatest difficulty in reconciling themselves to the idea that the immense differences which exist between members of different phyla have arisen by slow and minute changes. Indeed, Goldschmidt has gone so far as to postulate two grades of micro- and macro-evolution. While the latter theory is inacceptable to the majority of evolutionists, nevertheless there are grave objections to the acceptance of Carter's position, which he omits to discuss, largely because he fails to take sufficient account of the plasticity of organisms at all stages of their lives. Further, the fact, so clearly stated by Waddington among others, that it is the phenotypic responses of the gene complex upon which selective forces operate is accorded too little consideration. As a consequence, scant regard is paid, on one hand to the canalization of genetic change through such phenotypic selection and possibly also by genetic assimilation, and on the other to the potential for sudden switches in evolutionary direction resulting from the operation of cænogenetic and neotenic changes.

The criticisms which have been offered clearly apply to the theory rather than to its treatment by the author, and it would be ungenerous not to add that he has provided an eminently readable and lucid account of the origin and evolution to date of the neo-Darwinian theory, which will be welcomed by many students.

L. A. HARVEY

THE GENUS *ACHLYA*

The Genus *Achlya*

Morphology and Taxonomy. By Terry W. Johnson, Jr. (University of Michigan Studies—Scientific Series, Vol. 20). Pp. xv+180 (22 plates). (Ann Arbor, Michigan: University of Michigan Press; London: Oxford University Press, 1956.) 36*s*. net.

DURING the past few years increasing interest has been taken in those families of fungi which have their main representatives living in aquatic habitats. They are usually called aquatic fungi though several are found in soil, a habitat first indicated by Butler in 1907 for some species of *Pythium*.

Achlya is the largest genus in Saprolegniaceae, with about a hundred described 'species'. It is characterized by the zoospores on discharge from the zoosporangium immediately encysting outside the orifice to form a loose, hollow, spherical cluster. Saprolegniaceae were last treated fully by W. C. Coker in 1932 in a monograph which stimulated research and, as a consequence, is now in need of much amplification. The present monograph is an excellent example of how such work should be done.

Understandably, some of the older specific descriptions were confused for, as likely as not, they dealt with a mixture of fungi rather than a single entity. In the present study more than 800 isolates and numerous specimens have been examined; all species have been redescribed from living or preserved material where available.

The introduction (18 pp.) gives an excellent survey of special points in the genus: vegetative characters; asexual and sexual reproduction; germination; historical summary of taxonomy; occurrence; collection; isolation and culture; preservation of cultures; taxonomic criteria; terminology. *Achlya* may be found in almost any freshwater source and in a diversity of soil habitats. A large number of different 'baits' have been used in the past, but present-day students "have come to utilize hempseed 'bait' almost exclusively for the collection, propagation, and maintenance of their isolates"—as many of us did forty or so years ago.

In the systematic account the genus is divided into three subgenera, *Achlya*, *Centroachlya* and *Subcentrica*, according to how the oil globules are arranged in the mature oospore.

Following a definition of the subgenus there is a key to its species. The species, with its synonymy, is fully and clearly described, followed by a list of the material examined and one of recorded collections. A longer or shorter note gives reasoned and useful information on matters of taxonomy and the like. Each species is clearly figured in the plates. Two sections deal with "Taxa of doubtful affinities" and "Excluded Taxa".

The monograph is set out clearly, with well-reasoned discussions, and the publishers have done their part equally satisfactorily. The only two points I would criticize are: the constant use of the term taxon, where species is more appropriate, and the uncertain treatment of names of species published after 1935 without Latin diagnoses and, therefore, illegitimate. The author provides a Latin diagnosis for one such species, which appears as *Achlya diffusa* Harvey ex Johnson, but discusses certain others, as he must, though, in effect, 'the names do not exist'. The only other new name is *Achlya cambrica* for *A. americana* var. *cambrica*, which Trow described in 1899 and which played so prominent a part in the violent discussions about sex in Saprolegniaceae which lasted for several years.

The modern tendency is to narrow species concepts but, as the author himself says, the trend in the present work is to broaden them, which it is clear he has done as a result of extensive study.

JOHN RAMSBOTTOM

COLORIMETRY

The Measurement of Colour

By Prof. W. D. Wright. Second edition. Pp. ix+263. (London: Hilger and Watts, Ltd., 1958.) 52*s*. net.

THE first edition of this book (1944) must have gained Prof. W. D. Wright many friends. No other author has taken such pains to explain in simple terms the principles of colorimetry, its applications and field of usefulness. The objective of still greater clarity has motivated some of the re-writing of the second edition, which at the same time brings in new material—a section on colour television, for example—and jettisons some earlier descriptions of now obsolete visual instruments. That considerable difficulties are experienced by those newly approaching the measurement of colour is undeniable. Yet the concepts involved are essentially simple and the mathematics required is elementary. Two probable stumbling blocks for the tyro are first, his own preconceived but mistaken idea that a sensation is being measured for which some particularly subtle method will be needed, and secondly—a purely technical difficulty—the use in colorimetry of the trichromatic or T-unit. One of the main improvements in this second edition is in the explanation of the T-unit, which is now carried through without any admixture of luminosity considerations. A metallurgical analogy of the T-unit is also provided which may help some. But one wonders whether the real solution would not be to rid colorimetry of the T-unit altogether. In my opinion much would be gained in clarity and even in economy of treatment by developing the subject from the three colour-matching functions and by regarding all problems as in principle three-dimensional ones to be handled in terms of tristimulus values. The transition to the usual two-dimensional chromaticities can easily be made at any stage, and no explicit introduction of a T-unit would be needed. From his comments on p. 109, Prof. Wright appears to be half converted to this view. If he would cross the Rubicon there is little doubt that other colorimetrists would follow.

With an extension of the standard colorimetric system of the International Commission on Illumination (C.I.E.) in prospect, the fuller account now given of the work—due principally to the author and Mr. J. Guild—which led to the 1931 system, is most opportune. Another good feature is the expanded treatment of colour atlases and of subjective judgments of colour and colour differences. This omits theore-

tical elaborations but gives the essentials that are of colorimetric interest. Two slips may be noted: the attribution to Planck of Kirchhoff's law on black-body radiation (p. 4), and the transposition of two colour patterns in the diagrams of Plate 4. Incidentally, the publishers may be complimented on the printing and layout, which are a great improvement on the first edition.

As an easily understood introduction to colorimetric practice, Prof. Wright's book remains unsurpassed.

W. S. Stiles

CLOUD PHYSICS

The Physics of Clouds

By Dr. B. J. Mason. (Oxford Monographs on Meteorology.) Pp. xx+481. (Oxford: Clarendon Press; London: Oxford University Press, 1957.) 70*s*. net.

During the past ten years the subject of cloud physics has been firmly established as one of the most lively and exciting branches of meteorological science. Although the actual number of persons working in this field is small compared with those in other branches of either meteorology or physics, their enthusiasm and initiative have enabled great progress to be made—from both an experimental and theoretical point of view, but particularly the former. Dr. B. J. Mason, who has himself made many contributions to the subject in recent years, has, therefore, rightly decided that now is the appropriate moment for the production of an authoritative and comprehensive account of past, present and possible future developments in the field.

One can say immediately that it is an excellent volume, and although it has been written primarily for the atmospheric physicist, its scope and interest should reach considerably further than this. To any experimental physicist the elegance, ingenuity and simplicity of some of the numerous techniques described cannot fail to appeal. The use of the diffusion cloud chamber for the study of the growth of ice crystals and the 'spider's web' method for the examination of droplets are two such examples. The physical chemist and the applied mathematician are by no means left out, and it is rather surprising and refreshing to find a contemporary branch of physics in which classical principles and methods of analysis are dominant.

Dr. Mason has set out to achieve three main objects in this book. First, to present a logical description of the physical processes by which the essentially microscopic process of condensation of water vapour upon an 'atmospheric' nucleus can lead to the formation of a cloud on the macroscopic scale. Secondly, Dr. Mason has taken great pains to make the book not only an account of the present state of knowledge about the subject, but also a volume in which a research worker can be sure that he will find reference to innumerable relevant papers and articles which have been published in the past. This task in itself must have been immense, since it has been recognized for many years that one of the main difficulties about the subject has been the large amount of technical information lying hidden in numerous journals. The third object Dr. Mason has had in mind is to emphasize the very important link which must be established between laboratory experiments on one hand and meteorological measurements on the other. It is not so much that in the laboratory parameters may be controlled, whereas in the atmosphere this is effectively impossible; it is in the mode of thought and interpretation that the link must be forged. Too frequently in the past the laboratory worker has failed to work out the way in which results of small-scale experiments can be made relevant to the larger field of atmospheric phenomena. Equally, the atmospheric physicist has often been very short-sighted in deciding between what can and cannot be measured with reliability and significance.

The book starts with an introductory chapter (written by Mr. F. H. Ludlam) in which the large-scale physics of clouds is discussed; actually, the main purpose of this chapter is to explain how a classification of the principal classes of clouds may be achieved. On the whole this chapter is too short, and although the photographic illustrations are excellent, there could have been more discussion in the text about some of the features they exhibit.

Dr. Mason then proceeds to a discussion of the condensation process in clean, ion-free air; although the book is mainly concerned with the condensation process in 'unclean' air, Dr. Mason rightly points out that, as an illustration of the method of approach to the general problem of nucleation, this more special but fundamental case of condensation is very valuable. A survey is given of the different methods employed by various workers (for example, Frenkel and Becker-Döring) on the subject, and it would have been worth while including a more detailed discussion of these methods and the physical ideas on which they are based.

The identification, concentration, size and sources of the various atmospheric nuclei are then dealt with, followed by an excellent discussion of the physics of the growth of droplets in cloud and fog. The important question of where snow and ice fit into the picture is very well presented and it is here, in particular, that the vital part that laboratory experiments (many of which are due to Dr. Mason and his research team) can play in the development of an understanding of the fundamental processes is well brought out.

The physics of the natural precipitation process is then fully discussed and a great wealth of material summarized. The making of artificial rain is described and a sensible and scientific appraisal of the possibilities of this technique is given. Immediately after this discussion of precipitation, some sixty pages are devoted to an explanation of the way in which radar has been used to give information about cloud structure; this technique is now so useful to the subject that it certainly merits the full and detailed analysis which is presented; this will enable those who are not so well acquainted with the physics of radar detection to appreciate its potentialities. Finally, there is a chapter on the electrification of clouds, and although the author stresses that no study of the mechanism of cloud formation (and disappearance) can be complete without taking into account the electrical phenomena, the summary at the end of the chapter is far too brief, and it is not easy to see how much of the work which has been done in this field can be correlated with the arguments and material presented in the earlier chapters.

The whole volume is well produced and the care with which the text, diagrams and many beautiful photographs have been prepared is very evident. Dr. Mason is to be congratulated on producing a book which not only reveals the present state of knowledge on the subject but also at last clarifies a wealth of previous observations and sets them in their correct perspective.

J. R. Atkinson

Behaviour of Metals at Elevated Temperatures

Lectures delivered at the Institution of Metallurgists Refresher Course, 1956. Pp. vii+122+3 plates. (London: Iliffe and Sons, Ltd.; New York: Philosophical Library, 1957. Published for the Institution of Metallurgists.) 21*s.* net.

THE ever-increasing temperatures for which engineers design and at which they operate their plant has made heavy demands on the metallurgist. The stability of alloys during long-continued stressing at elevated temperatures has been improved to an extent which is highly creditable to those through whose research and development work these new materials have been produced, but it is still true that changes in materials under stress at high temperatures are one of the main factors which retard engineering development in a wide range of fields. The book under review contains four lectures given to the Institution of Metallurgists in 1956 in which the present position is excellently surveyed and in which the main lines of future development are laid down. These lectures contain little which is absolutely new, but they all, in their own ways, represent most able critical reviews of the existing state of knowledge, admirably condensed and expressed in terms of immediate practical value.

These papers include one by Dr. N. P. Allen, of the National Physical Laboratory, on "The Engineering Properties of Metals at High Temperatures", which gives a general picture of the whole field which could scarcely be bettered. The other three deal with more specific sections: one on "The Effect of Temperatures up to 450° C. on Metals", by G. Meikle, of the Royal Aircraft Establishment, Farnborough; the second, by Dr. L. B. Pfeil, of the Mond Nickel Co., Ltd., on "Non-Ferrous High-Temperature Materials", which deals in large measure, though not entirely, with the outstanding range of high-temperature nickel and cobalt alloys, in the development of which Dr. Pfeil himself has played so significant a part; and finally, a paper on "High-Temperature Steels", by W. E. Bardgett, research manager of the United Steel Companies, Ltd. All these are well presented and illustrated, and the book as a whole represents a most useful contribution to the subject.

F. C. THOMPSON

Space Research and Exploration

Edited by Prof. D. R. Bates, in association with Patrick Moore. Pp. 224. (London: Eyre and Spottiswoode (Publishers), Ltd., 1957.) 25*s.* net.

THE great upsurge of interest in artificial satellites and space-flight during the past few years has opened the way for a flood of publications on the subject, not all of high scientific merit. The present book strikes a reasonable balance between the uninformed enthusiasm of the space-travel addicts and the sober scientific facts and problems in our limited knowledge of conditions on the fringe of the Earth's atmosphere and in interplanetary space. This book lays emphasis on the underlying principles of rocket propulsion and orbital mathematics and gives a useful appraisal of the possibilities of escape from the Earth's gravitational field and travel to other planets, with only a minimum of the customary optimistic speculation on more ambitious space voyages. A number of individual contributions have been brought together by the editors, covering all aspects of the subject, from basic rocket principles and performance, to the properties and likely biological effects of cosmic rays on would-be space-men. Inevitably, there is a good deal of overlap and variation in treatment, but the general aim of presenting a comprehensive and intelligible survey of the subject to the intelligent public is achieved. A few details of meteor statistics and orbital mathematics are given in appendixes; several minor errors occur, especially in Appendix 9. The most interesting part of the book is devoted to a summary of our present knowledge of the basic physical properties of the upper atmosphere, solar radiation, auroras, magnetic storms and ionospheric characteristics. The gaps in current knowledge and the exciting hopes of filling them by observations from satellites and research rockets are lucidly discussed in chapters by Prof. H. S. W. Massey, chairman of the British Gassiot Committee (which is responsible for scientific co-ordination of the British upper-atmosphere rocket-research programme). Due credit is given to the important results already gained from rocket measurements, although the superiority of artificial satellites as means of long-duration observation is recognized.

Miscelanea Geofisica publicada pelo Servico Meteorologico de Angola em Commemoracao do X Aniversario do Servico Meteorologico Nacional

Pp. v+366. (Luanda: Servico Meteorologico de Angola, 1956.) n.p.

THIS volume is a 'Festschrift' published on the occasion of the tenth anniversary of the national meteorological service of Portugal and Portuguese overseas territories and it is dedicated to the director, Dr. Amorim Ferreira.

It contains twenty-seven papers contributed from twelve different countries, including two by Portuguese authors. About half the papers are on the meteorology of central Africa but the others are on a wide variety of topics having no direct relevance to the meteorology of Angola. The two papers on Angola itself are both by German authors; K. Keil gives a bibliography of early meteorological observations in the territory and H. Flohn studies the equatorial west winds of Angola—two solid, informative papers. There are several papers on the climatology of the adjoining Belgian Congo. The other papers cover a very wide range, from oceanographic instruments devised in Japan to the precipitation of the Canadian prairies. J. Chase (Woods Hole) gives an interesting account with synoptic charts of the occasions when deep depressions have been near the Azores instead of the usual anticyclone. Dr. De Jong (Holland) discusses the construction and use of the composite charts drawn for aviation forecasting which show the isobars and fronts as they are expected to be when an aeroplane flying on a specific route reaches the corresponding area, and R. F. Murgatroyd describes the work of the British Meteorological Research Flight. There are mathematical papers by P. Defrise and others (Belgium) on the harmonic analysis of the height, kinetic energy and meridional flux of sensible heat on the 500-mb. surface at latitude 50° N., and by J. P. Peixoto (Lisbon) on Fourier spectral analysis in geophysical problems.

One cannot help feeling that it would have been preferable for some of the contributions not specifically related to Central Africa to have been published in the usual journals and not in a book of this kind where they will tend to be lost, and to have published in this volume only papers on the meteorology of Angola and the surrounding parts of Africa.

G. A. BULL

ABSORPTION AND TRANSLOCATION OF STRONTIUM AND CÆSIUM BY PLANTS FROM FOLIAR SPRAYS

By L. J. MIDDLETON

Agricultural Research Council Radiobiological Laboratory, Grove, Wantage, Berks, and Agricultural Research Council Field Station, Compton, Berks

OF the longer-lived fission products resulting from atomic fission, strontium-90 and to a lesser extent cæsium-137 are considered to present the major hazard to consumers of agricultural produce. The absorption of both nuclides by plants from soil has been studied extensively in the laboratory[1] and field experiments have also been carried out with strontium[2]. Less attention has, however, been paid to the absorption of fission products by the leaves of plants, though some experiments have been reported[3,4]. Over the past two years this problem has been examined in this laboratory as part of a general investigation of the passage of fission products through food chains.

A representative range of agricultural and horticultural crops (wheat, potato, french bean, swede, sugar beet and cabbage) were grown in pots or boxes. Replicated batches of plants were sprayed with strontium-89 or cæsium-137 at different stages of growth. When mature, the plants were harvested, divided into their various parts, and the concentration of strontium-89 or cæsium-137 was determined. Roots other than those of sugar beet or swede were not harvested. A randomized block design was adopted and appropriate statistical analyses were made.

Fall-out from nuclear weapons is known to vary markedly in composition and solubility according to such factors as the type of weapon, the altitude of detonation, the nature of the terrain and distance from the site of explosion. In the present experiments it was decided to apply the radioactive isotopes in carrier-free, completely soluble form in a fine spray equivalent to 6–7 ml./sq. yd. This, it was considered, would be comparable with long-range fall-out, which is known to be largely deposited in rain[5].

A precision sprayer was constructed incorporating a chamber designed to prevent the spread of radioactive materials. A section through the apparatus is shown in Fig. 1. The spraying chamber was constructed in two parts, the upper fixed (*A*), the lower movable (*B*). The lower part had double walls, with water in between; thus a gas seal could be maintained in all positions. On the undersurface of the chamber was an aperture with a projecting rim which fitted inside the edge of the box in which the plants were grown (*C*). Thus the box itself was not contaminated. The soil was protected with 'Cellophane' so that only the plant was exposed to the spray. The spraying mechanism, based on one designed by the Agricultural Research Council Unit of Experimental Agronomy, Oxford, was mounted above the chamber. A single Teejet (*D*), driven at a constant speed of 1·3 m.p.h., projected through a rubber flange (*E*) running the length of the chamber. The radioactive isotopes were applied at a rate of 30–90 μc./sq. yd. The apparatus has proved very satisfactory in use; when the chamber was exhausted by means of a fan for 5 min. after spraying, the concentration of strontium-89 or cæsium-137 in the air was reduced to negligible levels, even when quantities of the order of 5–10 mc. were sprayed in experiments not reported here. No contamination was recorded in the room in which the operation was carried out.

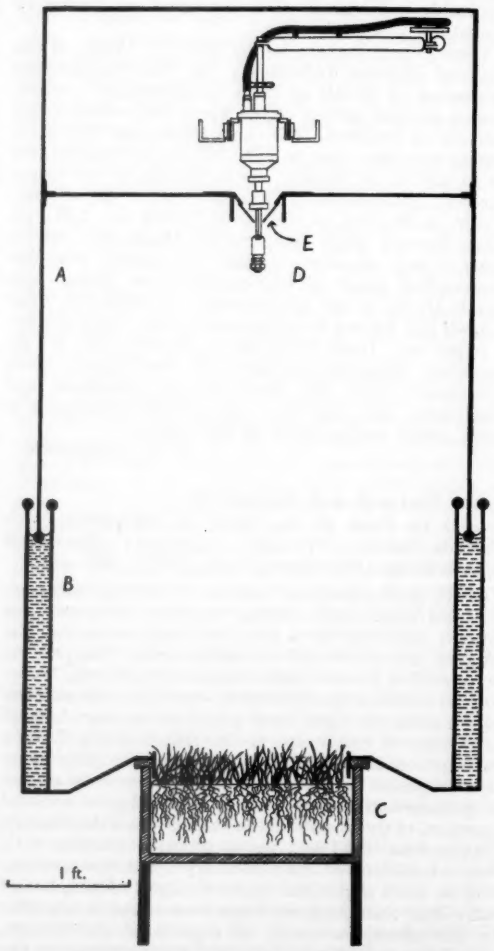

Fig. 1. Section through the precision sprayer

Table 1. Recovery of Strontium-89 and Cæsium-137 sprayed on the Foliage of Agricultural Crops as Percentage of Initial Deposition

	Strontium-89				Cæsium-137			
	P_1	E_1	E_2	E_3	P_1	E_1	E_2	E_3
Wheat (Atle)								
Straw	85·4†	14·0	17·9	81·4†	81·3†	20·2	16·7	61·4†
Chaff	0·161	0·186	3·62†	29·0†	2·88	3·17	3·57	29·0†
Grain	0·0188†	0·0436	1·07†	0·736†	9·18	8·84	9·41	3·18†
Total	85·6	14·2	22·6	111	93·4	32·2	29·7	93·6
Time interval (days)*	56	56	51	7	56	56	51	7
Rainfall (in.)	3·80	3·80	3·80	0·01	3·80	3·80	3·80	0·01
Potato (Majestic)								
Haulm	57·0	28·8	49·6		35·2	19·9	34·7	
Tuber	0·418	0·371	0·545		23·9	25·3	29·2	
Total	57·4	29·2	50·1		59·1	45·2	63·9	
Time interval (days)*	70	70	56		70	70	56	
Rainfall (in.)	6·39	6·39	4·97		6·39	6·39	4·97	
French bean (Canadian Wonder)								
Leaves and stems	68·1†	27·8	19·4		20·6†	12·0	13·0	
Pods H_1	0·277	0·280	—		11·2	9·60	—	
H_2	0·0791†	0·228	0·436		2·62	2·41	2·90	
H_3	0·0377†	0·128	0·235		0·096	0·171	0·356	
Total	68·5	28·4	20·1		34·5	24·2	16·3	
Time interval (days)*	60	60	32		60	60	32	
Rainfall (in.)	4·97	4·97	2·76		4·97	4·97	2·76	
Cabbage (Primo)								
Outer leaves	4·60	2·42	15·9†		5·42	4·86	34·7†	
Inner leaves	0·460	0·328	1·04		0·816	0·908	1·51	
Total	5·06	2·75	16·9		6·14	5·77	36·2	
Time interval (days)*	89	89	32		89	89	32	
Rainfall (in.)	6·56	6·56	2·76		6·56	6·56	2·76	
Sugar beet								
Tops	—	12·1	—		—	12·5	—	
Roots	—	1·62	—		—	4·92	—	
Total		13·7				17·4		
Time interval (days)*		90				90		
Rainfall (in.)		7·23				7·23		
Swede (Dunns Defiance)								
Tops	—	0·689	0·595		—	0·709	0·368	
Roots	—	0·965	0·811		—	3·37	1·57	
Total	—	1·65	1·41		—	4·08	1·94	
Time interval (days)*		110	82			110	82	
Rainfall (in.)		9·19	7·22			9·19	7·22	

* Time interval between spraying and harvest (days).
† Significantly different from treatment E_1.
P, protected from the rain by polyethylene covers; E, exposed to normal rainfall.
Subscripts refer to times of spraying.

After spraying, the plants were placed in a greenhouse for one or more days depending on the weather, and were then usually exposed to natural conditions outside. In an attempt to estimate the removal of radioactivity from the plants by the action of rain, some plants were protected from the rain by polyethylene covers. All plants were watered as necessary, care being taken to avoid wetting the leaves.

Autoradiographs indicated that the solutions were initially deposited in discrete droplets over the surface of the plant. Later the pattern of radioactivity became more diffuse. The movement of strontium-89 was very limited and parts of the plants not directly exposed to the spray contained very little radioactivity. Cæsium-137, on the other hand, appeared to enter the veins readily and move to all parts of the plants.

Quantitative results are presented in Table 1. The radioactivity of each sample is expressed as a percentage of the initial deposition on the plant, which was determined by the assay of samples immediately after spraying. Allowance has been made for radioactive decay so that the results obtained with strontium-89 are applicable also to strontium-90. The time intervals between spraying and harvest and rainfall are also shown in Table 1.

Wheat was sprayed on three occasions: just as the ears emerged (E_1 and P_1 in Table 1); one week later when the ears had emerged fully (E_2); or one week before harvest (E_3). It was found that only 20 per cent or less of the strontium-89 or cæsium-137 initially deposited on to the plants was recovered from the straw of plants exposed after spraying for the longer periods. This was attributed largely to the action of rain, since plants protected from the rain (P_1) or exposed for only a short period (E_3) retained a much larger proportion. The chaff from plants sprayed after the ears had emerged (E_2, E_3) contained a large amount of strontium-89 relative to those plants in which the ears were not directly exposed to the spray (P_1 and E_1). In the latter, the strontium-89 content of the chaff was considerably less than 1 per cent. In contrast the amount of cæsium-137 was as high in chaff from ears not directly contaminated by the spray (P_1 and E_1) as in chaff from plants sprayed shortly after the emergence of ears (E_2). Considerably more cæsium-137 was recovered from chaff from plants sprayed shortly before harvest (E_3).

Less than 0·1 per cent of the strontium-89 initially deposited on the plant was found in grain from ears which emerged after spraying (P_1 and E_1). When the plants were protected from rain after spraying

(P_1) the strontium-89 content of the grain was significantly lower than when the plants were exposed to rain (E_1). The strontium-89 content of the grain was more than twenty times greater when spraying occurred after the ears had emerged but while the grain was still immature (E_2), and the values for the final spraying occasion (E_3) were only slightly lower. The latter result may have been largely due to superficial contamination, since the strontium-89 content of the chaff was very high for the E_3-treatment. The fraction of the cæsium-137 applied to the plant which was found in the grain was very much higher than that of the radiostrontium, reaching nearly 10 per cent. In contrast with strontium-89, the time of spraying did not affect this value except when plants were sprayed on the last occasion (E_3). The grain from these plants contained less cæsium-137 than the grain from those previously sprayed.

Potatoes were sprayed either just as the tubers began to form (E_1) or two weeks later (E_2). Relatively large boxes were needed for this crop and this limited the number of replicates. Thus the precision of these experiments was low and no significant differences exist between treatments. The recovery of radioactivity in the haulms was low. Since the recovery was far from complete in treatment P_1, the loss of radioactivity cannot be attributed entirely to rain. Only 0·5 per cent of the strontium-89 applied was transferred to the tuber; the corresponding value for cæsium-137 was 25–30 per cent.

French bean plants were sprayed either just after the first flowers formed (P_1 and E_1) or 4 weeks later (E_2). Three harvests of pods (H_1, H_2 and H_3 in Table 1) were made, 3, 6 and 9 weeks respectively after the first time of spraying. Pods which had been exposed at the time of spraying were washed before assay. The total recovery of both radioactive isotopes from plants exposed to rain was one-third or less of the radioactivity initially applied. 70 per cent of the strontium-89 applied was recovered from plants protected from the rain while only 20 per cent of the cæsium-137 was recovered from plants similarly treated. Less than 1 per cent of the strontium-89 initially applied was found in the pods. The amount decreased with successive harvests especially in plants protected from the rain (P_1). The strontium-89 content of pods harvested on the first occasion after spraying (H_1 and H_2 for treatments E_1 and E_2 respectively) was greater when the plants were sprayed on the second occasion, (E_2). This was due perhaps to direct absorption of the radiostrontium through the walls of the pods. More than 10 per cent of the cæsium-137 initially deposited on the plant was recovered from the pods in some treatments. There was again a marked decrease with successive harvests. The decrease with time in the content of both strontium-89 and of cæsium-137 in the pods was very much greater than the decrease of the total radioactivity of the plant.

Cabbages were sprayed either as the hearts were beginning to form (P_1 and E_1) or one month before maturity (E_2). The recovery of both strontium-89 and cæsium-137 was low except from the outer leaves of plants sprayed on the second occasion. This appeared to be largely due to the deciduous nature of the outer leaves since protection from the rain had little effect on retention. The transference of both radioisotopes to the heart tissues was low.

Swedes were sprayed either when the storage organs were very small (E_1) or when they were partly formed (E_2). The recovery of cæsium-137 or strontium-89 from the tops was extremely low. This was largely due to the loss with ageing of the leaves which had been exposed to the spray. A greater proportion of cæsium-137 than of strontium-89 was recovered from the storage organs.

Sugar beet was sprayed only when the storage organs were beginning to develop. Recovery from the tops was low. More cæsium-137 than strontium-89 was recovered from the storage organs.

The present results are compatible with the conclusions of other workers that strontium is redistributed in plants to only a small extent[6] whereas cæsium is relatively more mobile[4]. The appreciable fraction of the cæsium-137 deposited on the plant which may be absorbed and translocated to developing organs contrasts with its relatively low availability from the soil[7]. The detailed discussion of the problems of plant physiology raised by the results is deferred until more comprehensive data are available. The present results, however, provide some information on the extent to which the edible parts of the crops might be contaminated if they were exposed to fall-out during the period of growth. The exact degree would clearly depend on many factors, for example, the solubility of the fall-out, the extent of the rainfall and the rate of growth and mineral status of the plants. The radioactive isotopes used in this investigation were completely soluble and in that respect represent the worst case. The results have been expressed in terms of the initial deposition on the plant, and it is to be remembered that the relation between deposition on the plant and deposition per unit area will vary according to the proportion of the ground surface which is covered by the particular crop.

The quantity of strontium-89 or cæsium-137 recovered from the plants at maturity varied with the treatment after spraying. A comparison of the recovery from plants protected from the rain (P_1) and from those exposed to normal rainfall (E_1) showed that a considerable proportion of strontium-89 or cæsium-137 sprayed in freely soluble form was afterwards washed off by rain. However, other factors besides rainfall were of importance since recovery was not complete even when there was protection from the rain. This may be due to some radioactivity reaching the roots which were not harvested; this is especially likely in the case of the more mobile cæsium-137. A more important factor may be the loss of radioactivity on dead leaves, particularly in the case of the cabbage, swede and sugar beet.

The deposition of strontium-89 on an immature ear of wheat, and thus close to the developing grain, resulted in a relatively high strontium-89 content of the grain, compared with plants sprayed before the ear had emerged. It is therefore possible that the period shortly after ear emergence is critical with respect to contamination of wheat grain by strontium-89. The cæsium-137 content of grain was not affected in the same way. This contrast reflects the difference in the mobility of the two ions.

With french beans there was a striking fall in the content of the pods in successive harvests, which was relatively greater than the fall in the content of the whole shoot. It is possible that this is a result of competition in the supply of nutrients between contaminated leaves and leaves which have developed after spraying. In crops in which there is continual

production and decay of leaves (sugar beet, cabbage, swede) a considerable protective factor may exist if the fall-out is of short duration and the leaves directly exposed die before the crop is harvested. Another protective factor may lie in the high degree of waxiness on the leaf surfaces of plants such as the cabbage, which may limit absorption.

The advice of Dr. R. Scott Russell and Dr. R. C. Campbell and the technical assistance of W. A. Mitchell and J. Revill is gratefully acknowledged.

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RECENT ADVANCES IN POLYMER TECHNOLOGY

A JOINT conference of the Institute of the Rubber Industry and of the Plastics Institute was held at the Institution of Civil Engineers in London on February 27, in which lectures were delivered on recent scientific and technological developments. These industries, outwardly disparate in aims and applications, both rest on the bed of polymer technology. Despite this link, each industry has independently developed its own organization, institutions and qualifications, but it is interesting to note how modern theories of long-chain polymers are producing a merger of these fields of interest, attested by the great success of the recent joint conference.

The programme was designed to give expression both to the more scientific aspects of these industries and also to developments in processing techniques. These two groups of lectures were run simultaneously but the two general lectures by Sir Harry Melville and by Prof. G. Gee could be enjoyed by the entire audience. It seems fitting in this brief account to give more prominence to these general lectures and also to those of a more scientific content.

The first lecture, by Sir Harry Melville, served as an interesting introduction to the new aspects opened up by recent discoveries of methods of modifying the physical arrangement, as distinct from the chemical structure, of polymers. It has always been difficult, for example, to drive the polycondensation reaction to yield products of very high molecular weight. It is now possible, however, to achieve very long chains by coupling the chain-ends through the use of di-isocyanates. Thus, short-chain polyesters or polyethers can be lengthened and, if dissimilar polymers are used in the di-isocyanate reaction, block polymers can be prepared.

Another problem has been the difficulty of detecting and measuring the degree of branching in synthetic polymers. Research on this problem has led to methods for making deliberately branched polymers, including graft co-polymers, which term is used to describe those branched polymers where the branches differ chemically from the main chain polymer. Methods for preparing graft co-polymers include the radiation method to create frozen-in free radicals, the synthesis of polymers containing hydroperoxide groups which could then be made to react with ferrous ions to produce polymeric free radicals, methods involving the rapid mechanical transport from a zone activated by illumination to a new environment containing another monomer and methods involving mechanical shear. There are far fewer practical methods for the production of block co-polymers, however.

Sir Harry Melville then discussed the distribution of molecular weights in synthetic polymers. In practice most distributions are approximately random. The production of polymers with a very narrow distribution is, however, possible in theory, provided that one can introduce a regulated termination step. For example, one can use an emulsion system subjected to radiation. With a single burst of radiation, propagation reactions are started and continue until another burst of radiation is released which terminates the majority of the chains. Alternatively, a flow system can be designed in which growing chains are quickly delivered into a solvent containing a polymerization 'short-stop'. These methods narrow the distribution, but a completely uniform distribution, as for a natural protein, for example, has not yet been achieved.

Sir Harry Melville finally directed attention to the work relating to new types of catalysts. A development of very great importance is that of heterogeneous catalysts which, operating by an ionic mechanism, bring about facile polymerization and determine also the internal conformation or molecular geometry of the polymer. In the case of polybutadiene and polyisoprene, for example, several entirely different products can be obtained simply by varying the nature of the catalyst. These new techniques, not unnaturally, are bringing many problems in their train, and the polymer scientist is assured of a continuing supply of fascinating new problems to take the place of those which have been solved.

The second general lecture, opening the afternoon session, was delivered by Prof. Gee, who dealt with the rubber-like state. There is a close analogy between molecular movement in liquids and the segmental contortions in polymers which are responsible for high elasticity and the rubber-like state. Deviations from ideal elastic behaviour will be observed when the polymer is in a glassy state, when it is capable of crystallization and when it is subject to very high rates of dynamic strain. Qualitatively, these deviations can be interpreted in terms of two independent properties of a polymer—its intermolecular forces and its molecular stiffness.

There are two approaches to the measurement of intermolecular forces, based on the concepts of cohesive energy density (C.E.D.), or of internal pressure (P_i). There are also several ways of expressing or evaluating the property of molecular stiffness. Solution techniques, such as light scattering, allow

estimation of the minimum spherical volume which can enclose the whole molecule. More direct approaches to the behaviour of a molecule in relation to its neighbours are available through the examination of internal relaxation phenomena or the measurement of melt viscosity.

It is particularly useful to examine the dependence of the melt viscosity of a polymer on the environmental pressure. This leads to a value for ΔV, the volume element which must be adjacent to a molecular segment to allow it to move. For low molecular weight polyisobutylene, ΔV is found to be independent of temperature at low temperatures, and to be so large that it is obvious the molecules move as a whole. With rising temperature ΔV decreases so that the polymer begins to move as several segments. Prof. Gee concluded his lecture by giving examples of the effect of structure on intermolecular forces and upon molecular stiffness, showing that they lead to predictions of mechanical behaviour which correspond with experience.

One of the most interesting sessional lectures was that given by Dr. W. F. Watson, of the British Rubber Producers Research Association, on chemical reactions induced by polymer deformation. Plastic shear is known to lead to occasional bond rupture with the formation of free radicals. This is the direct result of the input of mechanical energy and is not due to thermal effects resulting from friction. The reactions have a negative temperature coefficient because of their dependence on viscosity. As the viscosity increases, so the dissipation of mechanical energy for a given shear rate must increase and therefore the number of free radicals produced. In the absence of oxygen the free radicals may re-combine, and the net effect is small. In the presence of oxygen, however, the chain ends are stabilized, presumably by the formation of hydroperoxide groups. This mechanism is supported by observations made in the presence of additives acting as radical traps.

Dr. Watson also discussed blends of rubber with carbon black. It is known that reactions between the rubber and carbon black occur during milling such that the blend, if given one pass in a mill, is rendered insoluble in benzene. However, if this stock pigmented with carbon black is milled in the presence of 0·5 per cent diphenyl picryl hydrazyl acting as a radical trap, the product is soluble, even after five passes in a mill, and gives a black suspension if placed in benzene. The picture created is that the rubber chain-like molecules normally become attached to superficial quinonoid groups on the carbon black particles during milling. Since diphenyl picryl hydrazyl has the power of stabilizing ruptured rubber molecules, this bridging action of the rubber molecules between neighbouring carbon black particles will be counteracted by the chain-fracture process. As a result, the carbon black particles remain separated and the blend of rubber and carbon black as a whole remains soluble.

The formation of radicals by mechanical shear is by no means confined to natural rubber: it occurs with almost any other type of polymer provided it can be deformed while in a rubbery condition. Degradative effects, occurring at temperatures much below that required to produce any thermal degradation, are observed, for example, with cellulose acetate and, to a somewhat lesser extent, with polystyrene and polyvinyl acetate. These techniques have allowed new families of co-polymers to be made by milling their mixtures. Thus an adhesive for polyethylene can be made by milling polyethylene with polyisobutylene above the softening point of the polymer.

Graft co-polymers can also be made by this technique, and Dr. Watson exhibited a number of curves demonstrating that a wide variety of monomers can be fully polymerized if they are added in small amount to rubber and milled for a short time. It is not possible to separate the newly formed polymer from the original rubber, indicating that true chemical linkage of the monomer to the rubber had taken place with the formation of a graft co-polymer. The important economic question of the input of mechanical energy necessary to bring about the formation of a given weight of new polymer was not discussed, however.

The allocation of two lectures to the subject of radiation effects serves to illustrate the growing importance of high-energy radiation in the processing of polymers and elastomers. In a paper entitled "Radiation of Polymers", Prof. A. Charlesby (Royal Military Academy of Science, Shrivenham) gave a comprehensive general review of the sources of high-energy radiation and of their effects on materials.

Two groups of radiation sources are available: those based on nuclear disintegration, as in nuclear reactors, fission products and radioactive isotopes, and those involving electrical equipment capable of accelerating particles (usually electrons) to high velocities. The basic radiation-induced reactions are similar whichever source is used, and the choice between them is determined primarily by availability, beam penetration and radiation intensity. At present, electrical sources are considerably cheaper for large-scale work where the electron penetration is adequate and high intensities of radiation can be tolerated. Nuclear sources of radiation are likely to be used in those fields where low intensities or high penetration involving γ-radiation are essential.

Owing to the high cost of radiation, applications are at present mainly confined to reactions in which valuable products are obtained, to chain reactions initiated by radiation or to the modification of materials where small chemical changes can produce large changes in physical properties.

Work on polymerization has led to interesting developments in the production of graft polymers, and in this application the ability of radiation to produce radicals in the solid state can be fully utilized. The use of radiation to produce block co-polymers can also be envisaged, particularly in cases where a polymer is degraded under irradiation.

Another use of radiation is in the curing of unsaturated polyester resins, which proceeds via a chain reaction. Here, radiation serves only to initiate the reaction and no catalysts are required. Better control of the curing process is therefore possible, and the properties of such polyesters have been studied as a function of the degree of cure.

Most reactions so far studied in detail have involved radicals, resulting indirectly from the primary radiation process and not differing in any way from those produced by chemical methods. Recent work has shown that ionic reactions can also be initiated by radiation and, furthermore, that the yield can be greatly increased by the addition of simple inorganic materials acting as catalysts. These discoveries should greatly extend potential application of radiation.

Turning to the modification of polymers, Prof. Charlesby referred to the processes of cross-linking and degradation, which do not proceed by a chain reaction. Their influence on mechanical properties was outlined and in the case of polyethylene, which has been most closely studied, the irradiated product is complementary to the newer high-density polyethylenes; radiation improves resistance to cracking and decreases flow at high temperatures. However, at temperatures above the melting point, mechanical strength is low, and to raise the modulus, fillers may be incorporated. The mechanism of reinforcement has been most closely studied in the case of carbon black used as a filler for rubber, and two distinct types of reinforcement have been observed.

Prof. Charlesby concluded by pointing out that, with the rapidly decreasing cost of radiation, the economical potential of the technique is greatly increased. However, there is a danger that large-scale industrial development may outstrip basic research in this new field; he therefore entered a strong plea for closer collaboration between the universities and industrial laboratories.

The second lecture dealing with high-energy radiation, entitled "Radiation Processing", was read by Mr. T. Bain, of Tube Investments Research Laboratories. This lecture was almost solely confined to the irradiation of polyethylene, for which the advantages are most clear. Despite the promise of an abundant supply of radioactive isotopes as an off-shoot of Britain's nuclear energy programme, Mr. Bain considered that electron accelerators are now, and would continue to be, the most practical sources of radiation for the modification of polymers. Following the detailed description of the characteristics of the 2-MeV. van de Graaff electron accelerator, which is being operated at the Tube Investments Research Laboratories near Cambridge, Mr. Bain discussed the practical aspects of processing of various types of products such as electrical components, film and cable. Estimates of production capacity and irradiation costs for this type of machine were given. It was emphasized that while irradiation processing is still in the development stage and is consequently relatively expensive, it already has a number of commercial applications which may be expected to expand rapidly in the future as more experience in the field is accumulated and as cheaper irradiation sources become available. The lecture was illustrated by a number of slides revealing particular methods for handling various types of materials, and the release of this 'know-how' stimulated a number of pointed questions in the ensuing discussion.

Another subject given prominence during the conference was the preparation and properties of foamed materials, probably on account of its common interest to both rubber and plastics industries. The first lecture, entitled "Urethane Foam Processes", was given by Dr. J. T. Watts, of Imperial Chemical Industries, Dyestuffs Division. The type and quantity of raw materials used influence the type of foam; variations are obtainable from soft flexible foams to hard rigid structures. The latter can be made by mixing the ingredients by a batch process, but the high reaction speed in the case of the flexible foams renders continuous mixing machinery highly desirable.

Mr. F. Chapman, of Whiffen and Sons, in a lecture entitled "Expanded P.V.C." described the manner in which the production of expanded polyvinyl chloride of all types progressed rapidly over the past few years. In general, either chemical blowing agents or carbon dioxide gas are used to produce the desired expansion. The expanded polyvinyl chloride is non-inflammable and has an excellent future as a core material for many types of structural laminates, not to mention its possibilities as upholstery and marine and buoyancy materials.

The third lecture in this group, by Mr. A. Cooper (Expanded Rubber Co.), on "Properties of Cellular Polymers", was mainly concerned with the general properties of foamed polymers, such as the number of cells per unit volume, the high- and low-temperature behaviour and mechanical, electrical and acoustical properties.

There were two lectures by overseas visitors. That given by Mr. H. A. Braendle (Columbian Carbon Co., U.S.A.) was entitled "Masterbatching Techniques". After reviewing the early history of the rubber industry, Mr. Braendle defined the masterbatch as a pre-dispersion or mix of one or more ingredients in a basic polymer, which may later be combined with other ingredients or even other masterbatches to make a variety of products. Such techniques lead to greatly improved dispersions of the pigments in the final products. Among pigments used to reinforce rubber, carbon black is probably the most important and Mr. Braendle's lecture was largely confined to this pigment.

In the new processes, the carbon black is kept suspended not by colloidal action but by continuous violent agitation, and suitable machines for this dispersing operation were described in some detail. The 15 per cent improvement claimed is attributed to the elimination of dispersing agents which block off active sites on the carbon black that would otherwise be available for forming rubber-to-carbon bonds. Mr. Braendle hoped that the successful use of carbon black reinforcement in the rubber industry would encourage the use of this material for the reinforcement of plastics, and closed his lecture by referring to examples in which the incorporation of carbon black into plastics has led to their more useful application.

The other overseas contribution was that given by Dr. C. P. Pinazzi (Institut Française du Caoutchouc) entitled "Hydroxymethyl Resorcinol Polycondensates in Rubber". The incorporation of such polycondensates leads to quite remarkable improvements in mechanical properties; the elastic modulus in particular is greatly increased. Dr. Pinazzi described his work on the synthesis and isolation of resin precursors in the resorcinol polyformaldehyde system. This led up to a study of their condensation reactions in organic solution and in the presence of certain elastomers. The preliminary indications are that chemical reactions take place between hydroxymethyl resorcinols and certain rubbers leading to properties analogous with those obtained in rubbers reinforced with carbon black.

The breadth of coverage of this joint conference is manifest from the subject of the lecture by Mr. R. H. Dykehouse (Cooke and Dykehouse Plastic Machinery Co.), which was on the practical and economic importance of preplasticizing equipment to the moulder and its ultimate effect on industry. This lecture dealt chiefly with the influence of commercial pre-plasticizing units and other aspects of injection moulding and was particularly directed at the injection moulding engineer.

S. H. Pinner
A. Charlesby

OBITUARIES

Sir James Swinburne, Bart., F.R.S.

Sir James Swinburne, who died at Bournemouth on March 30, a month after his one hundredth birthday, had a long and distinguished career, and played a major part in the early days of two important modern industries—electricity and plastics.

Born in Inverness and educated at Clifton College, James Swinburne trained on Tyneside during 1874–81 and became an engineer. His early career brought him into association with J. W. Swan and Co., and he was responsible for establishing electric lamp factories in Paris and Boston. Later he joined forces with Crompton and worked with him for three years in dynamo development and manufacture. Among his many contributions to electrical progress may be mentioned the hedgehog transformer, the first self-acting compound constant-potential dynamo and a great variety of electrical measuring instruments. In 1894 Swinburne began to practise as a consulting engineer and was frequently called upon to give technical evidence in patent cases. He soon acquired a reputation for clear, honest and expert evidence and his services were in constant demand, frequently extending his activities outside electrical engineering to include, for example, pneumatic tyres, gas mantles and the phonograph. In 1902 he was elected president of the Institution of Electrical Engineers, and among several predictions in his presidential address he forecast the all-electric home and the long-distance electric railway.

During his consulting work, Swinburne found himself involved in many different industries, and one day he was shown a resinous material produced from phenol-formaldehyde by an Austrian chemist named Luft. This resin, neither truly crystalline nor liquid, was typical of many similar products of chemical reaction which for years had been regarded as completely useless by the organic chemists of that time. Swinburne, however, brought his clear logical reasoning to bear on the problem of turning Luft's resin into something of commercial value. He realized that it was important to develop a method for taking the synthesis of phenol-formaldehyde to completion and eventually he established a condensation process in which sodium hydroxide was used as a catalyst.

He delayed applying for a patent in the hope of improving the method, but when in 1907 he did try to file a patent, it was to find that he had been anticipated by Baekeland working in America, by only a few weeks. Even so, Swinburne's contribution to the then revolutionary thinking which led to the creation of the plastics industry was of fundamental value, and he continued his work in this field, producing lacquers and impregnating varnishes which were soon to be of importance during the First World War. During the War his company, the Damard Lacquer Co., Ltd., concluded an agreement to make use of Dr. Baekeland's patents in Great Britain, and later Damard was amalgamated with Mouldensite, Ltd., and Redmanol to form Bakelite, Ltd. Swinburne was chairman of Bakelite, Ltd., until 1948 and remained on the Board until 1951, when he became honorary president of the company—a post which he held until his death.

Apart from his work, Swinburne had many interests, including music and sociology—he published a book in 1924 on "Population and the Social Problem". After retirement, he took up horology, and at the age of ninety-two he even published a book, "The Mechanism of the Watch".

Swinburne was a descendant of the second baronet, and succeeded to the baronetcy in 1934 on the death of the eighth baronet, Sir Hubert Swinburne. He was elected a Fellow of the Royal Society so long ago as 1906 and was a member of the Institution of Civil Engineers from 1894, and he was also one-time president of the Faraday Society. He was married twice, first in 1886 and then in 1898 to Lilian Carey, who survives him.

Mr. A. H. G. Alston

Arthur Hugh Garfit Alston, who died at Barcelona on March 17, was one of our foremost systematists. He was born at West Ashby, Lincolnshire, on September 4, 1902, the youngest son of the Rev. F. S. Alston. After Marlborough, he entered Lincoln College, Oxford, in 1921, and took his degree in 1924. Leaving there he worked for a short time in the herbarium at the Royal Botanic Gardens, Kew, and was then appointed systematic botanist to the Department of Agriculture of Ceylon, being stationed at the Royal Botanic Gardens at Peradeniya. He there laid the foundations of his wide knowledge of tropical plants, and wrote a supplementary volume to H. Trimen's well-known "Handbook to the Flora of Ceylon", and "The Kandy Flora", published in 1931 and 1935 respectively.

Alston left Ceylon in 1930 and entered the Department of Botany, British Museum (Natural History), filling the vacancy caused by Dr. A. B. Rendle's retirement. The reorganization of the Cryptogamic Herbarium was taking place and Alston was put in charge of ferns. There was much to be done and he set about it in good heart, so that now it is probably the finest fern herbarium anywhere. He was anxious to specialize, and I remember well how we discussed which was the most neglected, and the most difficult, of the large genera. *Selaginella* fitted the bill well; he applied himself to its study with characteristic thoroughness, and within a few years became the recognized authority on the genus. At the same time he gradually extended the scope of his studies and, while publishing numerous papers on *Selaginella*, worked out many general collections of ferns, until he became generally regarded as the world's foremost authority on Pteridophyta as a whole. He recently completed an account of the ferns of West Tropical Africa.

Meanwhile, Alston remained interested in flowering plants and was as knowledgeable about them, probably, as anyone of his generation. Not only was he a keen herbarium man, but also he was a born collector, visiting the Continent every year, except for the war period, especially the Balkans and Spain, though he ranged from Sweden to Algeria. His main collecting trips were to central America (Venezuela, Colombia and Panama) in 1938–39, and to Java, Sumatra, Borneo and Celebes in 1953–54, at the invitation of the Indonesian Government. In 1946, he reported on the condition of the German herbaria, a report published by BIOS. From 1936 he had photographed type specimens, mainly of ferns, to be found in

European herbaria; the collection numbers about ten thousand.

His knowledge of books of travel, and of botanical collectors, was outstanding, and he readily gave information to anyone wishing it. Visitors to the Department, particularly those about to make their first botanical expeditions, found in Alston both inspiration and sound practical advice about how, where, and what to collect, and how to preserve and transport their finds. Many friendships were begun in this way which were mutually beneficial.

He was an active collector of British plants, of which he had a wide and critical knowledge. He could have written an interesting and valuable account of the natural history, local manners and customs, and literary associations of his native Lincolnshire, in which he always had a pride.

Usually somewhat reserved in manner, Alston could be very good company, and took obvious pleasure in being with congenial companions. With his knowledge, his culture and his courteousness, everything should have been at his feet; but, strange as it may seem in one who showed no concern about going off on his own in difficult country, he was strangely lacking in ability to deal with some very ordinary affairs and was impatient of any routine matters which inconvenienced him in his studies. I am sure he would have wished to be given authority, but he would have resented having little time for research. To make things more difficult for him, he had several break-downs in health from which, however, he seemed to recover completely.

It is a sad blow to taxonomic botany, both in Britain and abroad, that his death should have occurred when he was botanically in his prime.

JOHN RAMSBOTTOM

Dr. J. M. Nuttall

DR. J. M. NUTTALL, for many years a member of the staff of the Physics Department of the University of Manchester, died on January 28.

John Mitchell Nuttall was born on July 21, 1890, at Todmorden in Yorkshire, and entered the honours physics school at Manchester in 1908. He graduated in 1911 with a first-class degree in a brilliant year which included Sir James Chadwick and the late Prof. H. R. Robinson, sometime vice-chancellor of the University of London. Nuttall was awarded a graduate scholarship and began research with Geiger under the direction of Rutherford, who was then at the height of his powers, and had in his department, in addition to those already mentioned, Andrade, Bohr, Darwin, Fajans, Marsden and Moseley. Nuttall's work with Geiger was very successful and resulted in the discovery of a relationship which later became known as the Geiger–Nuttall Law.

At the outbreak of the First World War, Nuttall joined the Yorks and Lancs Infantry, but later transferred to the Field Survey Battalion of the Royal Engineers. He was promoted to the rank of captain and was twice mentioned in dispatches. In 1920 he returned to Manchester as senior lecturer in physics, and in the following year was made assistant director of the Physics Department under Prof. (now Sir Lawrence) Bragg. Prof. P. M. S. Blackett succeeded Bragg as director of the Physical Laboratories in 1938, and when he left for War Service in 1939 Nuttall took charge and continued to act as head until 1944. He retired in 1955.

Former colleagues and students who remember Nuttall in his prime will recall his nimbleness of mind and his powers as a *raconteur*. His wit enlivened his lectures.

The academic world has lost a man distinguished for his early work in radioactivity, and one who gave devoted service to the University of Manchester. His many friends will remember his loyalty, integrity, generosity and native Yorkshire wit.

Dr. Nuttall is survived by his wife, who sustained and cheered him during some years of ill-health, and by his son, Dr. Kenneth Nuttall.

G. D. ROCHESTER

NEWS and VIEWS

Zoology at Sheffield : Prof. L. E. Eastham

PROF. L. E. EASTHAM retires at the end of the current academic year from the chair of zoology in the University of Sheffield, which he has held since January 1932. Trained in the Departments of Agriculture and Zoology at the University of Leeds, his first appointment was lecturer in zoology at Birmingham in 1921. In 1927 he went to Cambridge as lecturer in advanced and economic entomology, holding this post until he left for Sheffield. His main zoological interests have always been entomological. His first considerable body of research was on the embryology of the butterfly *Pieris* and the formation of germ-layers in insects. Later, he published an important series of papers on metachronal rhythms and gill-movements in ephemerid nymphs, returning quite recently to an elucidation of problems of the feeding mechanism of *Pieris brassicae*. His high standing as an entomologist has been enhanced by his co-authorship of the standard zoological textbook on "The Invertebrata" known to thousands of students as 'BEPS', a new edition of which appeared earlier this year.

The Department of Zoology at Sheffield has grown greatly during Eastham's tenure of the chair and has long been a notably active as well as a conspicuously happy and friendly part of the University, features very largely due to Eastham's scientific and administrative competence and to his kindly wisdom. These qualities explain both why students of all kinds have constantly sought his help and advice and why he was appointed first holder of the newly instituted pro-vice-chancellorship. After his four years of unsparing service in this office, he has continued to be consulted as an elder statesman, and the University will sadly miss his genial sagacity. Eastham's activities extended far outside his Department and University. Since 1945 he has been a member of the Northern Universities Joint Matriculation Board, serving as chairman during 1949–52 and again during 1955–58. He has also been a member of the Inter-University Council for Higher Education in the

Colonies since its establishment in 1946. In these and in many other spheres he has maintained the high standards of conscientiousness, sagacity and humanity for which he is so well known.

Prof. I. Chester Jones

Ian Chester Jones, who has been elected to succeed Prof. L. E. S. Eastham in the chair of zoology at Sheffield, obtained a first-class degree in the honours school of zoology at Liverpool in 1938 and received the degree of Ph.D. in 1941. His war service was in the Army, from which he emerged with the rank of major in 1946 and returned to Liverpool as assistant lecturer. Apart from two years at Harvard in the tenure of a Commonwealth Fund Fellowship, he has remained at Liverpool as lecturer and senior lecturer. Dr. Chester Jones's research since the Second World War has lain wholly within the general field of comparative endocrinology which he has done much to create and of which he is one of the most distinguished exponents. His monograph on the adrenal cortex (1957) is the first serious attempt at a general synthesis of what is known of that puzzling gland in every class of vertebrate. In 1954 he organized an extremely successful symposium at Liverpool on comparative endocrinology, the report on which, edited by him and Dr. Eckstein, has since appeared as the fourth and fifth memoirs of the Society for Endocrinology. He has earned for himself at Liverpool an enviable reputation by his ability both to train and to inspire young post-graduate students. At Sheffield his opportunities will be greater, and it is to be assumed that the grants-in-aid which have supported his work so far will be continued on a scale appropriate to the new circumstances. A well-known text-book on vertebrate zoology opens with a paragraph on the need for generality: and it is just this quality which has been most conspicuously lacking in the treatment of endocrinology until recently. Dr. Chester Jones's high reputation rests, in part, on his early recognition of this need and on his sustained effort to meet it.

Secretaryship of the International Commission on Zoological Nomenclature

Mr. Francis Hemming, who has been honorary secretary to the International Commission on Zoological Nomenclature since 1936, is to retire on account of ill-health. He has also been advised that he ought not to incur the physical strain involved in completing the arrangements for the Colloquium on Zoological Nomenclature which is to be held in London next July immediately before the meeting of the Fifteenth International Congress of Zoology.

With the consent of Sir William Pugh, director of the Geological Survey, London, and with the approval of the Department of Scientific and Industrial Research and of the Treasury, Mr. R. V. Melville, a senior member of the palæontological staff of the Survey, has been released for a period of one year to become assistant secretary to, and director of, the Commission. In addition, Mr. Melville has been appointed assistant manager to the Trust. His first duty will be to obtain suitable accommodation for the office of the Commission (which hitherto has been housed rent-free in Mr. Hemming's private residence) and to complete the arrangements for the meeting of the Colloquium on Zoological Nomenclature. Mr. Hemming has consented to see through the press the edition of the "Official Lists" and "Official Indexes" now in preparation and, in addition, to prepare the "Opinions" required to give effect to the decisions already taken by the Commission in a number of cases. Mr. Hemming has also agreed for the time being to retain the position of managing director and secretary of the Trust. In view of the close association between the work of the Section on Nomenclature of the International Congress of Zoology and the work of the Colloquium on Zoological Nomenclature, Sir Gavin de Beer, as president of the forthcoming Congress, has invited Mr. Melville to act as recorder for the Section in succession to Mr. Hemming.

Working Party on Higher Education to visit East Africa

After consultation with the Governors of Kenya, Tanganyika and Uganda and the British Resident of Zanzibar, the Secretary of State for the Colonies, Mr. Alan Lennox-Boyd, has appointed a Working Party on Higher Education which is to visit East Africa in mid-July. The chairman will be Dr. J. F. Lockwood, vice-chancellor of the University of London, and the members will be: Dame Lillian Penson (professor of modern history, University of London), Sir David Keir (master, Balliol College, Oxford), Prof. E. Giffen (Queen Mary College, University of London) and Prof. L. E. S. Eastham (University of Sheffield). The secretary will be Mr. I. C. M. Maxwell. The terms of reference are as follows: (1) To examine and advise on the proposals for the creation of new institutions of higher education in East Africa and to advise on their desirability and scope, and on the timing of their establishment. (2) To examine and advise on the pattern of future development of higher education in East Africa; and in this connexion to examine the desirability and practicability of carrying out any such development within the scope of a single university or university college of East Africa of which all colleges territorially situated would be constituent units. (3) To examine and advise on the additional facilities, if any, for higher technological and professional training, which are required in East Africa.

Translations of Russian Scientific Literature

In replying to a question on the translation of Russian scientific and technical literature in the House of Commons on April 29, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that the Department of Scientific and Industrial Research is giving considerable thought to this difficult problem and is urgently considering ways and means of expanding the number and availability of the translations. The Lord President did not accept the implication in the question that it is a waste of time for research scientists to learn Russian, but he fully recognized the great importance of the matter and would do everything possible to accelerate the service requested. Mr. Nicholls reiterated that normally the best translations of scientific and technical papers are produced by working scientists with a knowledge of Russian. The Lord President had no knowledge of detailed arrangements in the United States but was aware that some Russian scientific and technical periodicals were being translated by commercial agencies there. There appears to be no advantage in separate translations of the same documents into English being made on both sides of the Atlantic. Mr. Nicholls agreed that we should

play our part but made no comment on the statement that it cost 50*s*.–70*s*. per thousand words to obtain a translation, and referred again to the discussions on co-operation in this field proceeding between the Department of Scientific and Industrial Research and the National Science Foundation.

The Professional Engineers Appointments Bureau

THE Professional Engineers Appointments Bureau, now of 39 Victoria Street, Westminster, S.W.1, in its report for 1957 states that a steady demand for engineers of all grades was maintained, although some reduction in the numbers of vacancies notified became apparent toward the end of the year. Enrolments of engineers with the Bureau showed no obvious fluctuations and were similar to 1956, although not so high as in the two previous years, when approximately 2,000 enrolments were recorded. The number on the register was comparatively constant throughout the year, enabling fair selections to be made for the majority of vacancies notified. Notified vacancies covered most branches of engineering, many being located in areas widely spread over the world. Civil engineering especially offered some interesting and well-paid posts abroad, whereas vacancies in the mechanical and electrical branches tended to be for design, development and research engineers, based in the United Kingdom. The more senior posts were mainly managerial or administrative. Salary and location requirements insisted upon by individuals continued to be the major factors governing the selection and numbers of placings achieved. Engineers seeking guidance on careers were given assistance, and advice was offered when difficulties arose in securing positions which would be regarded as carrying professional responsibilities. The number of engineers from the Armed Services increased on account of the reduction in personnel in the Forces and some success was achieved in placing many of these men in civilian posts. There was a continued increase in those over fifty registering with the Bureau, without any comparable increase in vacancies for which employers were prepared to consider men in this age-group. Efforts initiated by organizations interested in this difficult problem seemed to make no progress in improving the opportunities for these men. For this reason a more realistic attitude had to be adopted in discussing prospects before accepting their enrolment.

Higher Technological Education

THE ninth annual report of the Regional Advisory Council for Higher Technological Education, London and Home Counties, for the year ended August 31, 1957 (pp. 33. London: Regional Advisory Council for Higher Technological Education, 1957), refers to the setting up of a new committee to consider the location of courses, which has already held five meetings, while an organization committee has been examining the structure of the advisory committees. Some concern is expressed about recruitment for part-time agricultural courses, and in applied chemistry the London County Council was asked to consider limiting provision in its area to one sandwich diploma course in pure chemistry for the present. A new sandwich diploma course in pure and applied physics at the Brighton Technical College was supported and a diploma sandwich course in applied biology at the Brunel College of Technology (Acton). The Council adopted the report of a study group on the proposal to establish a college of advanced building technology in central London, and also approved a report of the committee on the regional provision of full-time and sandwich courses in civil and structural engineering. The Council also agreed in principle to concentrate sandwich diploma courses in electrical engineering in a relatively small number of centres. An increasing demand is noted for sandwich diploma courses in mechanical and production engineering. The theme of the fourth conference of lecturers in management subjects, in June 1957, was "Communications in Industry".

Technical Education in the Post Office

THE Post Office, in consultation with the trade unions concerned, has produced a scheme for increased facilities for technical education of technical staff. Until recently, such facilities (as distinct from the technical training which the Post Office itself supplies) have been available in normal circumstances only for employees under 18. The new scheme takes three forms—university bursaries, sandwich courses and a certain amount of release during the day for people over 18. It is proposed to award up to ten university bursaries each year for degree studies in technological and scientific fields to be granted to promising members of the staff. It is also intended to award up to ten sandwich course places each year to members of the staff selected on the basis of progress reports from technical colleges, paper qualifications, reports from supervising officers and a final group selection test. Details of the scheme for day release of staff are still under discussion. But the intention is that preference will be given to people who are already taking technical education during the day at their own expense, by taking special leave without pay; and to people for whom evening classes in the subjects they need are not available.

Building for Technical Education in Scotland

DETAILS of the technical education building programme of £10,725,000 covering projects in Scotland on which work is expected to start in the five years ending March 31, 1961, was given by the Secretary of State for Scotland in a written answer on April 1 to a question in the House of Commons. They included £160,000 for an extension to the Robert Gordon's Technical College, Aberdeen (for which plans and tender have been approved); £500,000 for an extension to Paisley Technical College; £400,000, £300,000 and £840,000 for new technical colleges at Ayr, Clydebank and Falkirk, respectively, for all of which the accommodation schedule has been approved. Plans have been approved for £132,000 for a new technical college at Inverness, and proposals are under consideration for a £600,000 extension to Kirkcaldy Technical College.

Scientific and Technical Students

IN a reply circulated with Hansard for April 3, the Parliamentary Secretary to the Ministry of Education gave the number of full-time students in further educational establishments who took engineering and craft courses leading to university degrees in 1956–57 as 1,594, and of part-time students as 994. A further 3,581 full-time and 83,569 part-time students obtained national diplomas and certificates; 192 and 71,131, respectively, took City and Guilds examinations, and 3,605 and 5,706, respectively, other examinations, including Dip. Tech. For science, the corresponding figures were: university degrees, 2,145 full-time and 3,348 part-time; national diplomas

and certificates, 68 and 16,307; City and Guilds examinations, 708, part-time; General Certificate of Education, 1,121 and 2,473; other examinations 813 and 2,989.

The Mathematical Association

The annual meeting of the Mathematical Association was held in Manchester during April 9–12. In his presidential address, Mr. W. J. Langford (headmaster of Battersea Grammar School) gave an international survey of secondary school mathematics. The dangerous shortage of mathematics teachers in Britain was set in its world perspective. Prof. M. J. Lighthill (University of Manchester), speaking in place of Prof. H. Behnke (University of Munster), who was too ill to attend the meeting, urged that boys and girls should be trained to apply their mathematics to life and not to regard it as a piece of ceremonial ritual. Mr. C. Mack, of the British Cotton Industry Research Association, discussed a variety of problems, including those of friction in textiles and 'ballooning' in spool winding. This was followed by a discussion on the Association's report on the teaching of algebra in sixth forms, opened by Prof. M. H. A. Newman, of the University of Manchester, the president-elect and chairman of the Committee which prepared the report. Prof. Newman's theme was that the teacher's aim in the sixth form should be to provide good proofs with gaps which could be filled at the university. He considered that it was a mistake to force logical difficulties on the schoolboy's attention. Dr. C. B. Hazelgrove spoke of the work done on the electric computers at the University of Manchester; he considered the possibility that machines may be programmed to do, not just computation, but work in logic and algebra which would make significant contributions to mathematics. Dr. P. L. Taylor (Metropolitan-Vickers) unexpectedly stressed the need to teach not only the technique but also the philosophy of mathematics. Dr. R. D. Davies described the Jodrell Bank Experimental Station and said that it was planned to use the large radio-telescope as a radar transmitter and in particular to obtain echoes from the planet Venus.

New Zealand Journal of Agricultural Research

Expansion of research in New Zealand has necessitated the appearance of the *New Zealand Journal of Agricultural Research*, the first number of which appeared in February 1958 (**1**, No. 1. Pp. 123. Published bi-monthly. Annual subscription: 30*s.*; single issues: 5*s.* Wellington: Department of Scientific and Industrial Research; London: High Commissioner for New Zealand, 1958). It is one of three new journals replacing the *New Zealand Journal of Science and Technology* which was divided into two sections dealing with agricultural research and general research, respectively. This new journal, which is published in alternate months by the New Zealand Department of Scientific and Industrial Research, is not to be confused with the monthly *New Zealand Journal of Agriculture* established in 1910 and published by the Ministry of Agriculture.

The Vanishing Prairie

Those who saw the delightful Walt Disney film, "The Vanishing Prairie", will be interested to know that the London County Council has sponsored the production of a film strip with the same title and based on the film itself. An introduction shows the extent of the prairie in the North American continent and how its fauna is changing and threatened with the advent of modern agricultural methods. Then follow stills of buffalo and bison, of natural formations created by erosion like Chimney Rock, Wyoming, the Rocky Mountain goat known locally as 'big horn', the coyote, the unforgettable stills from the film of the prairie dogs in their burrows and of cougars climbing trees. These and other stills from a film which scintillated with natural history photography will serve as good teaching material for a wide range of children and adults. The strip was made by Educational Productions Ltd., East Ardsley, Wakefield, Yorkshire, from which further details may be obtained.

United States National Museum

The annual report of the United States National Museum for 1957 (pp. v+137. Washington, D.C.: Government Printing Office, 1957) states that planning for the interior of the new Museum of History and Technology proceeded throughout the year. The programme of modernization, now in its fourth year, continued and included halls depicting everyday life in early America, the history of power machinery and the large mammals of North America. The public response to these new exhibits continued to increase during the year and comment on their effectiveness was encouraging.

Transvaal Museum, Pretoria

The annual report of the Trustees of the Transvaal Museum, Pretoria, South Africa, for the year ending March 31, 1957 (pp. 44. Pretoria: Transvaal Museum, 1957), deplores the difficult conditions under which the staff are obliged to work and the restriction of space which affects the exhibition and storage sections and prevents a full museum service for the public. Furthermore, in some cases, valuable exhibits are deteriorating. These are problems which, to a greater or lesser degree, confront museums throughout the world. The completion of the display rooms and cases in the Voortrekker Monument is reported, and an exhibition at the back of the Kruger House has been completed.

Personnel Management in the Small Firm

The recent development of personnel management in industry has been mainly confined to medium-sized and large firms. Many small companies have felt that it has little significance for them, and this view has been confirmed by the lack of suitable publications to help them. To fill this gap, Mrs. J. M. Collingridge and Mrs. J. M. Ritchie have prepared a broadsheet on behalf of the Institute of Personnel Management (Personnel Management in a Small Firm. Pp. 55. London: Institute of Personnel Management, 1957. 4*s.* 6*d.*). After analysing the content of personnel management, the authors describe its significance in the small firm and its functions under the headings of employment, training and education, wages, communications, health and safety, and employee services. Other sections deal with systems of personnel administration in small firms, conditions of effectiveness of personnel administration, other approaches to personnel administration and the place of the personnel officer in the small firm. There are also appendixes containing case studies of personnel management practice in a multiple retail firm and in a small firm with no personnel department.

Rothamsted Park Grass

THE park grass plots at Rothamsted, laid down in 1856 and continued with little change in treatment ever since, afford a unique opportunity of studying the effects of long-continued manuring with different types of fertilizer on the yield and botanical composition of hay. The experiment was one of Dr. Winifred E. Brenchley's chief interests, and at the time of her death in 1953 she had nearly completed a revision of her monograph, published in 1924, "Manuring of Grassland for Hay", which dealt with the results up to 1919, so as to include the data for the next thirty years. This revision is now being published (Rothamsted Experimental Station, Harpenden, Herts. 20*s*.) under the title "Rothamsted Park Grass, 1856–1949". Apart from some condensation and a few minor additions, little alteration has been made in Dr. Brenchley's revised text. The book provides the most recent data available on the botanical composition of the plots, as the regular hay analyses have been discontinued since 1949. Observations on the flora are, however, still being carried out, and the yields from two cuts of hay per annum recorded as before.

Forestry in Japan

IN Bulletin No. 102 of the Government Forest Experimental Station, Tokyo (Tokyo, 1957), Yoshio Matsushima, of the Government Forest Experimental Station, deals with some problems in Japanese forestry, from both the economic and scientific points of view. The investigations were carried out in the large province of Yoshimo, which contains several types of forest classified in Japan as natural forests, inaccessible and unworked, natural forests worked by the Government Forest Department, corporation forests, large private forests, small private forests, farm forests, and family forests. The unworked natural forests are situated on the tops and slopes of ridges where protection or a national safeguard is of first importance in the interests of water supplies and their continuity, which is well understood in Japan. Of the other types, the forests of the small landowner, farm forests and the family forests, the management is based on the intensive research carried out by the author and assistants from the research station. The smallest plots of land are not neglected, and expert advice on how to deal with them is available to the owners. The larger farm forests are not unknown in Yoshimo. They have labour to employ in the forest in the off-season for farming and supply their own requirements and sell the remainder at a profit. The interest and value of the author's investigations lie in the close study made of the small plots devoted to forestry by the small farmer and, above all, by the family. The labour for the first comes from the farm and is available when required. In the family forest plot the labour comes entirely from the family. On advice given they do the sowing or planting, supervise their small plot, and do the thinning and sales when necessary.

'Ledercort'

'LEDERCORT' is a new steroid with enhanced glucocorticoid and markedly reduced mineralocorticoid properties. Chemically, it is 9-alpha-fluoro-16 alpha-hydroxy-prednisolone. 'Ledercort' is claimed to be 10–40 times more active than hydrocortisone, and 3–12 times more active than prednisolone, in glucocorticoid activity. In its anti-inflammatory activity, it is 10 times more active than hydrocortisone. Unlike these older steroids, 'Ledercort' does not produce retention of sodium and water, and often depresses rather than stimulates the appetite. Because of its reduced dosage, there is a lower incidence of other side effects such as peptic ulcer, epigastric distress, drug psychoses and diabetic state. It is applicable, therefore, to those conditions which have hitherto responded to the hydrocortisone derivatives (for example, rheumatoid arthritis, bronchial asthma, dermatoses, and allergic disorders). 'Ledercort' is supplied by Lederle Laboratories Division, of Cyanamid of Great Britain, Ltd., in 4-mgm. tablets.

Artificial Earth Satellites

Two lengthy papers on artificial Earth satellites have appeared recently, in the *Irish Astronomical Journal* of September–December 1957 and the *Journal of the British Interplanetary Society* of January–February 1958. The first of these is an interesting paper entitled "Artificial Satellites", by Dr. E. J. Öpik, based on a lecture to the Dublin meeting of the British Association last year. Dr. Öpik discusses most aspects of the subject, including a history of developments up to 1957, a detailed description of satellite orbits and the conditions for visibility, an account of the effect of meteors and an outline of possible research programmes. It should be noted that, on p. 230, Table 9 (*b*) and the formula for the motion of perigee are in error: the formula ought to be $p_0\ (5\cos^2 i - 1)/2$, in Dr. Öpik's notation.

The second paper (*J. Brit. Interplan. Soc.*, **16**, 261; 1958), by D. E. Okhotsimskii and T. M. Eneev, is translated from Russian and has the title "Some Variation Problems connected with the Launching of Artificial Satellites of the Earth". This paper, which was presented at the Barcelona Astronautical Congress in September 1957, applies the calculus of variations to determine the optimum paths for satellite missiles during the powered climb from the Earth's surface. The optimum path *in vacuo* with constant gravity is established first, both for unrestricted propellant flow and for a specified flow. Then the problem is solved with a variable gravitational field and for a rotating Earth. Many of the results in the early part are familiar, but those in the later parts appear to be new.

Marine Biological Association of the United Kingdom

THE Marine Biological Association of the United Kingdom has accepted a grant of £12,000 from the Trustees of the Nuffield Foundation towards the cost of reconstructing the tanks of its aquarium at Plymouth. Part of the equipment of the Plymouth laboratory, which was opened in 1888, was a series of salt water tanks for experimental purposes. These tanks have always played a very essential part in the scientific activities of the laboratory, providing an opportunity of observing living animals under almost natural conditions. From the earliest days it was also realized that the tanks could fulfil a useful educational purpose; the tank room was very soon opened to the public, and to-day it has 80,000 visitors annually.

"Christopher Columbus" Prize for Communications

THE city of Genoa has instituted, in commemoration of Christopher Columbus, a prize of five million lire. This is conferred yearly on someone who has made an outstanding contribution to communications during the past four years. For the prize there are

four sections: maritime; air; land; and postal and telecommunications. This year the prize will be awarded for land communications. Nominations must be received by Prof. Antonio A. Copocaccia, Faculty of Engineering, University of Genoa, Via Montallegro 1, Genoa, before June 30.

Royal Institution

THE annual meeting of the members of the Royal Institution was held on May 1, with Lord Brabazon, president, in the chair. The following officers were elected: *President*, Lord Brabazon of Tara; *Treasurer*, Mr. W. E. Schall; *Secretary*, Sir Harold Spencer Jones. *Managers*, Dr. T. E. Allibone, Dr. H. D. Anthony, Mr. E. R. Davies, Sir Alfred Egerton, Dr. A. G. Gaydon, Prof. A. Haddow, Dr. H. Heywood, Brig. H. E. Hopthrow, Mr. E. Ironmonger, Mr. L. B. W. Jolley, Mr. James Lawrie, Dr. H. Lowery, Mr. J. A. Oriel, Mr. H. P. Rooksby and Mr. P. H. Schwarzschild. *Visitors*, Dr. F. H. Cotton, Sir Graham Cunningham, Prof. H. Dingle, Mr. A. J. Haselfoot, Miss E. H. Jebens, Mr. S. Rees Jones, Mr. W. C. Lister, Miss C. M. McDowell, Mrs. J. E. Milton, Mr. F. A. Mitchell, Mr. O. Parr, Mr. Neville Shepherd, Miss Daphne Sidebottom, Dr. P. C. Spensley and Dr. Norman Stuart.

Membership of the Nature Conservancy

THE Committee of Privy Council for Nature Conservation has appointed the following as members of the Nature Conservancy: Mr. A. Blenkinsop, M.P., Lt.-Col. C. M. Floyd, Major J. C. Morrison, M.P., and Dr. L. Dudley Stamp. The vacancies have arisen through the retirement of Mr. Geoffrey de Freitas, M.P., Sir W. Wavell Wakefield, M.P., Sir William Taylor (who remains a member of the Scientific Policy Committee and the Committee for England) and Capt. C. Diver (who also remains a member of the Scientific Policy Committee and the Committee for England). Mr. Michael Noble, Mr. A. R. Wannop and Prof. C. M. Yonge have joined the Scottish Committee, Dr. F. Fraser Darling and Dr. C. B. Williams having retired this year and Dr. E. Wyllie Fenton having resigned earlier. Prof. N. A. Burges and Dr. A. S. Watt have joined the Committee for England in succession to Prof. W. H. Pearsall and the late Lt.-Col. E. B. Buxton. On the Committee for Wales, Prof. W. G. V. Balchin and Mrs. I. M. Vaughan fill the vacancies arising from the retirement of Mr. L. J. Watson (who is now an observer on this Committee) and Mr. W. M. Condry.

Geological Society: Officers for 1958

AT the recent annual general meeting of the Geological Society of London, the following officers and council for the ensuing year were elected: *President*, Dr. C. J. Stubblefield; *Vice-Presidents*, Prof. L. Hawkes, Dr. W. Campbell Smith, Dr. F. M. Trotter, Dr. E. I. White; *Secretaries*, Mr. A. J. Butler and Mr. J. M. Edmonds; *Foreign Secretary*, Prof. O. T. Jones; *Treasurer*, Mr. P. Evans; *Council*, Dr. A. Allison, Prof. J. G. C. Anderson, Mr. A. J. Butler, Mr. J. M. Edmonds, Mr. P. Evans, Prof. T. Neville George, Prof. W. D. Gill, Mr. W. B. Harland, Prof. L. Hawkes, Mr. N. F. Hughes, Prof. O. T. Jones, Dr. W. S. McKerrow, Mr. T. C. Nicholas, Sir William Pugh, Prof. H. H. Read, Dr. P. A. Sabine, Prof. R. M. Shackleton, Dr. S. H. Shaw, Dr. W. Campbell Smith, Dr. C. J. Stubblefield, Dr. F. M. Trotter, Dr. E. I. White and Dr. G. Wilson.

Announcements

THE following have recently been elected to honorary fellowship of the Chemical Society: Prof. O. Hassel (Oslo), Dr. G. B. Kistiakowski (Harvard), Prof. Wolfgang Pauli (Zurich) and Dr. E. W. R. Steacie (Ottawa).

THE Moulton Medal of the Institution of Chemical Engineers has been awarded to W. D. Armstrong, H. H. Rosenbrock and W. L. Wilkinson for their paper published in the *Transactions* of the Institute and entitled, "An Investigation of the Transient Response of a Distillation Column, Parts 1 and 2". The Junior Moulton Medal for 1957 has been awarded to Dr. D. Train for his paper on "Transmission of Forces through a Powder Mass during the Process of Pelleting".

PROF. P. H. GREGORY, head of the Department of Botany, Imperial College of Science and Technology since 1954 (*Nature*, 172, 838; 1953), has been appointed head of the Department of Plant Pathology, Rothamsted Experimental Station, in succession to Mr. F. C. Bawden, who has been appointed director of the Station (*Nature*, 181, 158; 1958).

THE Development Commissioners give notice that, in association with the Ministry of Agriculture, Fisheries and Food and the Scottish Home Department, they will award postgraduate training grants in fishery research tenable from October 1, 1958. These grants are intended to enable selected candidates to undergo a specified course of training to fit them for the investigation of problems in marine or freshwater science. Candidates must be nominated by a senior member of a university department. Provisional applications will be accepted from candidates who have not yet sat their final examination or who have not yet been informed of the result. Forms of application, returnable by May 20, can be obtained from The Secretary, Development Commission, 3 Dean's Yard, Westminster, London, S.W.1.

A ONE-DAY meeting, organized jointly by the Scientific and Technical Group of the Royal Photographic Society and the Electron Microscopy Group of the Institute of Physics, on "Photographic Aspects of Electron Microscopy", will be held in the Arts School Theatre, Bene't Street, Cambridge, on May 30. Further information can be obtained from Mr. R. E. Withrington, Ilford Limited, Ilford, Essex.

FOR the seventeenth meeting of the European Federation of Chemical Engineering there will be a joint symposium on "The Organization of Chemical Engineering Projects" at Olympia, London, during June 24–26. This is also the occasion of the Chemical and Petroleum Engineering Exhibition, which will be held at Olympia during June 18–28. Further information can be obtained from the General Secretary, The Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

A LECTURE-DEMONSTRATION course on clinical biochemistry, organized by the Association of Clinical Biochemists, will be held in Birmingham during July 7–11. The course is intended for those having some postgraduate experience in clinical biochemistry. It will be of particular interest to those intending to take a higher qualification in the subject. Further information can be obtained from Mr. T. P. Whitehead, Group Pathological Laboratory, Lakin Road, Warwick.

SCOTTISH LURGI PLANT

ONE of the outstanding problems in present-day utilization of coal is that of using economically inferior fuels of high ash and moisture content. A most interesting development in this respect is the project undertaken by the Scottish Gas Board for the building of a gasification plant, costing ultimately some £6,500,000, to produce, from low-grade open-cast coal, towns' gas for distribution over long distances.

The process to be used is known as the Lurgi pressure gasification process, and the final capacity will be some 30 million cubic feet of gas a day. The Lurgi process has emanated from Germany, the gas being generated in the first stage of a series of operations by complete gasification of the coal in producers, pressurized to 25 atmospheres, in a continuous stream of oxygen and superheated steam. The gas produced in this way has a calorific value of 300 B.T.U. per cubic ft.

The heat in the crude gas will be used to raise steam in waste-heat boilers. Tar, oils and ammonia in the effluent will be recovered. Benzole, a valuable by-product, will also be recovered from the crude gas. The oxygen required for the process will be obtained from two air-separation plants, which also produce nitrogen. The nitrogen will be used for adjusting the combustion characteristics of the gas at the end of the process stream.

The Lurgi gas contains rather a higher content of carbon monoxide than is desirable for towns' gas purposes. Accordingly, the Lurgi gas will be subjected to a catalytic conversion of the carbon monoxide and water vapour in the gas to carbon dioxide and hydrogen. This reaction is carried out at high temperature and pressure in the presence of an iron oxide catalyst. The carbon dioxide is then washed out in a plant in which this gas and hydrogen sulphide, arising from the sulphur in the coal, are absorbed in a hot solution of potassium carbonate.

In the interim stage of the development, this gas, to the extent of 15 million cu. ft. a day, now having a calorific value of 400 B.T.U. per cu. ft., will be enriched with butane before distribution, thus raising its heating value to within the requirements of the gas grid. The final desulphurization of the gas, in order to meet the Gas Referees' Standards, will be made in pressurized oxide purifiers.

The subsequent development of the process will include an oil hydrogenation enrichment of the gas to a calorific value of 700 B.T.U. per cu. ft., the final dilution to the normal calorific value of 450 B.T.U. per cu. ft. being effected by means of nitrogen from the oxygen plant.

The site of the plant is to be at Westfield in Fife. The plant will be the seventh large-scale plant of this type in the world. It will take five years to complete the construction of the plant and to lay the associated high-pressure and medium-pressure grid mains. These will distribute the gas over an area extending from Angus and Perthshire in the north through Kinross, Fife and Stirlingshire to Lanarkshire and the Lothians.

This undertaking is a bold venture, which has many novel features in comparison with existing practice in gas manufacture. It is timely because it may well serve to demonstrate to industrialists the inherent potentialities of coal, and of its better use, at a time when an over-sanguine conversion to oil for heating purposes may be fraught in the future with possible economic dangers. R. J. SARJANT

TEACHING ZOOLOGY IN BRITAIN

THE Association of British Zoologists held its annual meeting in January in the rooms of the Zoological Society of London, and heard a series of papers on "The Natural Resources of the Country and their Value for Teaching and Research". Dr. J. H. Mundie (Freshwater Biological Association), speaking on the freshwater environment as a field of study, outlined the facilities which exist in Britain for studying freshwater ecology. He attached great importance to good ecological teaching in providing a map of the subject as a whole, and thought that present-day teaching is too factually detailed and passive, so that it tends to stifle the speculative and creative abilities of students. These abilities are found mainly in young people, upon whom the future of research largely depends. He thought that aquatic ecological research, which is essentially a field pursuit, is hampered by university regulations, by which postgraduates are obliged to spend most of their time in college. Commenting on applied problems, Dr. Mundie said that these lie mainly in the fields of water supply and water pollution and are, of course, directly related to human activities. He thought that there is a definite limit to satisfactory modification of the environment in the face of expanding industrialism, and that the best hope of securing conditions of reasonable living lies in adjusting the human rather than the environmental situation.

Speaking on the resources of the sea and the shore, Mr. G. M. Spooner (Marine Biological Association, Plymouth) stressed the great wealth and diversity of the British marine fauna, and gave figures showing the number of zoological specimens supplied each year from some of the marine laboratories in the United Kingdom. He also discussed some of the facilities available for research on marine animals, and the use made of them in fields not strictly concerned with marine biology, such as the important work on nerve physiology carried out on cephalopods. The exhibition of marine fauna in aquaria has, in the main, an educational purpose of considerable value. Under the heading of field study he stressed the importance of the intertidal zone, and mentioned that some areas showing interesting ecological conditions were threatened by the requirements of Service departments. He wondered whether in time the Nature Conservancy would not have to take into its care the intertidal zone in Great Britain.

Mr. T. H. Savory (Haberdasher Aske's School, Hampstead) spoke on the value of land invertebrates for teaching. He suggested that many advantages follow if young zoologists, even before they reach the stage of the Ordinary Level of the General

Certificate of Education, can be persuaded to interest themselves in, say, a group of common land invertebrates. He instanced earthworms, woodlice, grasshoppers and many others as examples of animals that are everywhere available, are still imperfectly studied, and of which the species native to Britain number less than fifty. These conditions provide a pupil with a manageable amount of material in which he may become a specialist. Mr. Savory believed that in this way a boy obtains more than fun from natural history; he can have a degree of satisfaction and even of pride in the work he is able to do. He is, moreover, taken away from the formal pages of the text-book, and makes his own acquaintance with the nature of zoology and with a zoologist's way of thinking. This is most apparent when, *en route* for scholarship honours, he enters a sixth form. "Scholars are bred in sixth forms", and despite the undeniable disadvantages of specializing, this early training may well supply one of the stepping-stones to success.

Speaking on the initial training of field workers, Mr. F. J. Bingley (Flatford Mill Field Centre) said that this forms one of the most important functions of the field centres run by the Field Studies Council. There are now five such centres, each with qualified staff, laboratories and student accommodation, and with courses in all branches of field biology. As an example, he described how, at the Flatford Mill Field Centre at the head of the Stour estuary on the Essex–Suffolk border, courses for biology students are run at three academic levels, including general ecology courses for those with no previous experience; specialized courses, for example, a freshwater biology course, where the students spend three or four days studying animal communities in different types of freshwater habitat followed possibly by a detailed survey of a stream and, on the last day, investigate some small problem on their own; and advanced courses for undergraduates and teachers, when the most modern field methods are taught by specialists. On all these courses attention is paid to fauna, flora and habitat, and emphasis is laid upon training in observation and the quantitative approach. Research workers also make use of the excellent facilities offered by the centres, and their results add materially to the teaching potential of the resident staff.

Dr. A. d'A. Bellairs (St. Mary's Hospital Medical School), speaking on the reptiles as a field of study, said that reptiles seldom figure prominently in the teaching of elementary zoology in Britain and, despite the fact that there are only six British species, much greater use might well be made of them. With their dry scaly skins and amniote eggs, the reptiles illustrate a more advanced stage in the colonization of the land than do any of our amphibians. Moreover, three British species are ovoviviparous, and can serve as a valuable source of living embryos. The slow-worm and the snakes are of further interest from a different point of view, for they are good examples of a particular type of extreme specialization, and provide an instructive contrast with the rather generalized animals which comprise most of the 'types' studied in courses of elementary zoology.

As a field of research, the reptiles present many problems in anatomy, physiology and behaviour. The recent observations of American herpetologists have shown the value of field studies, comparable with those which have been made for many years by ornithologists. Detailed and accurate observations on the territorial behaviour and the patterns of courtship in British reptiles would be of great interest; so also would studies of their temperature tolerances, following the work of C. M. Bogert and others in the United States. Many anatomical problems, for example, the possible presence of vestigial limb–nerve plexuses in snakes, also seem well worth investigating, even by comparatively simple techniques.

H. G. Vevers

PHOTOBIOLOGICAL INVESTIGATIONS

A MEETING of the Photobiology Group was held in Bedford College, London, on the afternoon of March 27. Three papers were presented and afterwards discussed. Dr. C. A. Parker (Admiralty Materials Laboratory) described "Recent Advances in Spectrofluorimetry and Chemical Actinometry". The ferri-oxalate actinometer recently developed by Dr. Parker is several hundred times more sensitive than the uranyl oxalate one used until recently, as well as having other useful features, such as linearity to light intensity over a factor of 10^6 and effectiveness from the far ultra-violet to the green. Its sensitivity permits its use for measuring spectral distributions, with narrow band pass filters, of daylight, discharge lamps, etc., and for calibrating spectrometer – photomultiplier set-ups, particularly in the ultra-violet region where other methods are very difficult. An instrument properly calibrated in this way can be used to measure the true shapes of fluorescence spectra. An even more valuable analytical method is to use a calibrated light-source spectrometer combination to excite fluorescence to determine a true 'action spectrum'; this should normally reproduce the absorption spectrum of the fluorescent substance even though the concentration is far too low for ordinary absorption spectroscopy. Examples were shown of the use of this method for analysing rubber extracts.

Dr. R. S. Spencer (Food Investigation Laboratory, Hull) read a paper on "The Biology of Luminous Bacteria". He showed that luminous organisms are widely distributed within the animal kingdom but less widely so within the plant kingdom, only certain bacteria and fungi being luminous.

Luminous bacteria would appear to have one main habitat, the seas and the creatures living in the seas, and several minor ones, namely, fresh water and certain terrestrial animals on which they are parasitic. They are frequently present in enormous numbers on spoiled and spoiling fish, where they are responsible for the luminosity of such fish, a phenomenon noted long before the bacteria themselves were discovered.

Many different species of luminous bacteria from marine sources have been named but it is possible that a critical study will show the actual number of species present in this habitat to be quite low.

Fish, of diverse species, harbour luminous bacteria on their surface and in their intestines, frequently in very large numbers. Current work with fish caught around the British Isles and in the Arctic

shows that only two species of luminous bacteria are present in significant amounts.

The physiology and biochemistry of the more common and well-studied species from marine sources show them to be well adapted to their environment. All will grow in the absence of oxygen and will luminesce at low oxygen concentrations. Many will grow and luminesce at temperatures around 0° C. Some, however, have relatively complex nutritional requirements in artificial culture, a possible indication that they are not free-living in the seas. As some species tolerate relatively high concentrations of bile salts, it is possible that their natural habitat is the intestines of fish.

Mr. E. S. Trickett (National Institute of Agricultural Engineering, Silsoe) described "Problems of Radiation Measurement in Relation to Environmental Control". The great difficulties of measuring the distribution of light and heat in glass-houses were pointed out. The wave-length range to be considered reaches from 3,000 to 30,000 A., and well beyond if thermal radiation has to be taken into account. The combination of spatial, temporal, and wave-length factors makes a very formidable problem. When to this is added the need for cheap detectors (existing ones cost several hundred pounds each), because monitoring must be carried out simultaneously at many different points, it is not surprising that research workers are still compelled to conduct growth experiments in glass-houses under very primitive forms of light control.

E. J. Bowen

DEVELOPMENT OF ARCHITECTURAL SCIENCE

A PUBLICATION* of the University of Sydney Extension Board contains twelve lectures and records of discussions, which were held in the autumn of 1956, on subjects under the general heading of "Structure and Architecture". Section *A* contains four lectures on mechanics; Section *B*, four lectures on æsthetics; and Section *C*, four lectures on construction. The purpose of the lectures is stated to be "to supplement the postgraduate work of architects and architectural assistants and to assist in maintaining interest in the study of the development of structure as related to architecture".

In the first lecture on mechanics, "The Traditional Architectural Forms and the Beginning of the Era of Scientific Structural Design", H. J. Cowan traces the development of the structural form of large buildings through the ages and suggests that its pattern is due to advances in materials and techniques as well as in theory of structures. An interesting account of the main stages in the earlier developments in the latter is included. The next lecture considers "One-dimensional Structures—the Invention of Steel and Reinforced Concrete Construction". It deals with the influence on structural design of the invention of high-strength materials such as steel and reinforced concrete on one hand, and the development of reliable theories for predicting the strength of structural members, on the other. The main result of these advances during the earlier part of the nineteenth century was an increase in the scale of the beam and column type of construction. The third lecture, "Two-dimensional Structures", is mainly concerned with the development of the theory of rigid two-dimensional frames since the middle of the nineteenth century, as a result, initially, of the work of Culmann, Ritter, Maxwell, Mohr and others and, more recently, of the powerful method of moment distribution due to Hardy Cross. The final lecture on mechanics by Prof. Cowan, "The Revival of Curved Roofs and of Three-dimensional Structures", deals with the recent development of integral three-dimensional structures of the shell type, largely as a result of advances in concrete construction techniques. The theory of arch and shell behaviour is outlined, together with the possibility of using experimental (scale model) techniques to circumvent mathematical analysis.

"An Historical Survey of the Influence of Structural Development on Contemporary Architecture" is the title of the first of the lectures on æsthetics. The lecturer, A. N. Baldwinson, suggests that the emotional neutrality of the architecture of many works of the nineteenth century reflects the cessation of the inclusion of the activities of the structural engineer in those of the architect, owing to the increasing complexity of the structural aspect due to new developments. It is noted that nowadays engineers and architects are co-operating, to the advantage of the æsthetic aspect. The principal events since 1735 which have influenced architectural development are noted in chronological order in an appendix. The subject of the lecture of F. E. A. Towndrow is "The Theory of Architectural Design in relation to Structures". Some contemporary theories in architectural æsthetics are described and the relevance of æsthetic theories to the work of the engineer is discussed with reference to the opinions of Arup and Nervi. The latter is quoted as saying that æsthetic considerations are fundamental. The place of æsthetics in all creative work is outlined, and the training of architects and structural engineers in different ways in separate schools is deplored. The third lecture on æsthetics, "A Painter Looks at Architectural Structure", is by Lloyd Rees and deals with the purely visual aspect. For example, the relationship of buildings to their surroundings is discussed, with emphasis on maintaining local character. It is suggested that one of the most inspiring features of modern structural technique is the covering of large areas without intermediate support. In the final lecture on æsthetics, "The Art of Space", R. B. Grounds asserts that the purpose of architecture is expression, the medium is space and the tool is building. Examples of the concept of space in the architecture of old and new buildings are given and it is suggested that greatness in architecture is only incidentally related to the technological methods employed.

The subject of the first lecture under the general heading of construction is "The Economics of Multi-story Buildings". In it, F. Woolard examines the factors which influence the cost of multi-story buildings and separates them into items of capital cost, running cost and maintenance cost, noting that

* Architectural Science No. 2: Proceedings of the Symposium on Structure and Architecture. Edited by Prof. Henry J. Cowan. Pp. xii+95–200. (Sydney: Sydney University Extension Board, 1957. Copies obtainable from Academic Press, Pty., Ltd.) 21s.

these costs are, to some extent, inter-related. Data on costs are given and a plea is made to architects to make cost data available to enable a close study of the factors which influence capital cost to be made. "The Drafting of a Modern Structural Code" is considered in a lecture by R. E. McMillan. It is suggested that such a code should cover standard specifications for materials and fittings and set out design criteria in respect of loads and stresses, but at the same time it should not be restrictive of new materials and design theories. Under the heading "Structural Engineering Practice in the Design of Buildings", R. A. Priddle deals with the function of the structural engineer in relation to the architect and other factors which influence the design of structures for various kinds of building. It is stated that under present building regulations (in Australia, presumably) the reinforced concrete frame is advantageous economically when there are to be more than five stories. Useful data on the cost of different kinds of construction in relation to stanchion spacing are given. The fourth and final lecture on the construction aspect has the title "Structure in Relation to Architectural Practice" and is by C. J. Farrington. The essential qualities of a structure are stated to be: satisfactory performance, economy and beauty, in descending order of importance. It is suggested that beauty has often been sought at the expense of performance and that human activity is hampered by 'fixed structures'. Mr. Farrington concludes: "it may be that some day the building will be nothing more than some kind of aerial field to repel the elements, and allow the human activity to go on unhampered beneath it".

T. M. Charlton

PLASMA APPROACH TO METALLIC CONDUCTION

By Dr. LOUIS GOLD

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PRESENT theory of metallic conduction is founded upon the individual electron behaviour as first conceived by Drude and later modified by Sommerfeld to allow for quantum considerations which introduce Fermi–Dirac statistics. It is rather strange that whereas plasma interaction has been invoked to account for the stopping power of metals[1] for incident high-energy particles and, furthermore, to explain the Ruthemann–Lang experiments[2] in particular, no theory has been advanced incorporating the plasma contribution to electrical conduction.

It is the purpose of this communication to show that a plasma approach to metallic conduction introduces a type of behaviour that is most suggestive for superconductivity. Indeed, normal and superconductive response may be construed as limiting modes of metallic conduction.

Recent work on plasma oscillations in gases[3] provides an interesting basis for viewing the conduction process in metals. The model employed is very much like that of the Bardeen and Frohlich quantum mechanical analysis[4]. The metal is taken to be a jelly of positive charge, vibrating as an elastic continuum, in which an electron gas (of charge density equal to that of the ions) is essentially free to move and interact within the matrix jelly. Correlation, exchange and band structure are ignored in this elementary approach. This formulation now embraces both the collective and individual electron interactions.

Dynamics of the plasma model for metals. The Boltzmann transport formalism is circumvented by making use of a phenomenological description, as was done in the Drude theory. Thus the individual damped acceleration of an average electron may be expressed as

$$m\dot{\mathbf{v}} + \nu m\mathbf{v} = q\mathbf{E} \tag{1}$$

where ν embodies collisional damping associated with impurity and lattice scattering.

Collective electron interaction next enters via Poisson's relation, which expresses the long-range coulombic forces acting:

$$\nabla \cdot \mathbf{E} = \frac{1}{\epsilon_0}\rho, \quad \rho = \rho_N - \rho_e \tag{2}$$

where ρ is the net charge density composed of the electron- and ion-charge densities, ρ_e and ρ_N, respectively. Any disturbance of the plasma will give rise to fluctuations in ρ_e which will be damped out with time. The ponderous ions are relatively immobile so that ρ_N is effectively constant, with $<\rho_e> = \rho_N$ for neutrality.

In one dimension, with electron motion along the x-axis, equations (1) and (2) become:

$$m\dot{v} + \nu m v = qE, \quad E \equiv E_x \tag{3}$$

$$\frac{\partial E}{\partial x} = \frac{1}{\epsilon_0}(\rho_e - \rho_N) \tag{4}$$

whereby elimination of E to get a velocity relation then proceeds via:

$$m\ddot{v} + \nu m\dot{v} = q\dot{E} = q\left(\frac{\partial E}{\partial t} + v\frac{\partial E}{\partial x}\right)$$

$$= q\left[\frac{\partial E}{\partial t} + \frac{1}{\epsilon_0}v(\rho_e - \rho_N)\right]$$

The conduction current $J = \rho_e v \gg \frac{\partial E}{\partial t}$ (displacement current), whence:

$$\ddot{v} + \nu\dot{v} + \omega_p^2 v - \omega_p^2 \frac{J}{\rho_N} = 0, \quad \omega_p^2 = \frac{q\rho_N}{m\epsilon_0} \tag{5}$$

Thus there are three types of solution for $v(t)$.

The auxiliary part of the solution may be

(*A*) Oscillatory, $\omega^2 = 4\omega_p^2 - \nu^2 > 0$
$c\exp(-\frac{1}{2}\nu t)\sin\frac{1}{2}\omega(t-\delta)$ (6*a*)

(*B*) Critically damped, $\omega^2 = 0$
$\exp(-\frac{1}{2}\nu t)(c_1 t + c_2)$ (6*b*)

(*C*) Strongly damped, $\omega^2 = \nu^2 - 4\omega_p^2 > 0$
$\exp(-\frac{1}{2}\nu t)\{c_1\exp(\frac{1}{2}\omega t) + c_2\exp(-\frac{1}{2}\omega t)\}$ (6*c*)

Plasma oscillation region. For small currents, $J = J_0 + J(t)$ with $J_0 \gg J(t)$ and $J \simeq J_0$. The oscillatory solution then becomes:

$$v(t) = c \exp(-\tfrac{1}{2}\nu t) \sin \tfrac{1}{2}\omega(t - \delta) + J/\rho_N \qquad (7)$$

from which it may be shown that[3]:

$$E = c\omega_p \frac{m}{q} \exp(-\nu t) \sin \tfrac{1}{2}\omega(t - \delta') + \frac{\nu m}{\rho_N q} J \qquad (8)$$

$$c^2 = \left(v_0 - \frac{J}{\rho_N}\right)\left\{1 + \frac{\nu^2}{\omega^2}\left[1 + \tfrac{1}{2}(J/\rho_N)/(v_0 - J/\rho_N)\right]^2\right\} \qquad (9)$$

with $\delta' = \delta - 2\varphi$, $\varphi = \sin^{-1}(\omega/2\omega_p)$. The initial condition has $t = 0$, $v = v_0$.

Thus the electric field is made up of an a.c. and d.c. component, which means that a portion of the electrons participate in the plasma oscillation while some are involved in normal conduction; as $t \to \infty$ the normal current prevails, namely:

$$\frac{E}{t \to \infty} \to \frac{\nu m}{\rho_N q} J$$

or $J = \sigma E$. The oscillating current may be identified with the superconducting electrons which form an ordered space charge as they execute the stationary Langmuir–Tonks oscillations.

The phenomenological treatment presupposed a constant ν. Actually $\nu \to 0$ as $T \to 0$ and so at some critical temperature, T_c the superconductive transition temperature, the co-operative electron vibration commences. As ν continues to decrease below T_c, equation (8) indicates that more normal electrons indulge in the organized motion until finally when $\nu = 0$ all electronic motion becomes organized.

Thus the plasma theory of metallic conduction predicts a transition temperature below which collective electron behaviour obtains, and that as the temperature continues to fall the two-fluid electron system experiences a gradual loss of normal electrons as they are converted to superconductive ones. For a d.c. external electric field, the superconductive electrons short-circuit the normal ones; but an a.c. external field will experience loss due to the normal electrons.

This explanation of superconductivity contains the notion of metastability, since equation (8) implies that $t \to \infty$ reduces all electrons to the normal state. Bloch's theorem is then obeyed, for the equilibrium state is not superconductive[5]. Some time ago Bohm[6] suggested a connexion between superconductivity and plasma oscillations, but did not develop the idea[7].

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[2] Pines, D., "Solid State Physics", 1367 (Academic Press, New York, 1955).
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COSMIC RAYS AND THE SUNSPOT CYCLE

A Large Cosmic-Ray Decrease accompanying the Solar Maximum of 1957

A NUMBER of observations of the general cosmic-ray level at balloon-altitudes have been made which show a very large decrease in intensity during the spring and summer of 1957 compared with 1955 and 1956. The observations are of two types, the first made with a small Geiger-counter vertical telescope at various latitudes in the central United States and Canada. Such a series was first carried out in 1955 and the results, together with the description of the instrument, have been published[1]. These measurements were repeated in June 1957 over part of the range of latitudes for comparison. The telescope has a stopping power of 0·2 gm./cm.^{2} and has an effective total angular aperture of 40°.

The other type of measurement is made with a combination of a single Geiger counter and an ionization chamber. A comparison is available with these instruments between the autumn of 1956 and summer of 1957 at Minneapolis. The single counter is 2 in. in diameter and has a sensitive length of 1$\frac{1}{2}$ in. with a brass wall 0·027 in. thick. The ionization chamber is closely similar to that described by H. V. Neher[2], and is 10 in. in diameter, has a steel wall 0·022 in. thick and contains argon at 8 atmospheres. The Geiger counter–ionization chamber package, together with nuclear emulsions, has been flown on many flights as part of the programme for the International Geophysical Year.

Fig. 1 shows the complete series of soundings obtained during August–September 1955 from latitudes 51·2° to 64·2° N., and soundings at three latitudes, near 51·2°, 55·3° and 58·6°, in June 1957. The vertical particle flux has decreased at all atmospheric depths less than 300 gm./cm.^{2}, and the change increases with decreasing depth until at high altitude and high latitude it almost reaches a factor of two. Furthermore, the Pfotzer maximum has shifted towards greater depths in the atmosphere.

In Fig. 2 is plotted the counting rate at a depth of 10 gm./cm.^{2} from each sounding. In some cases a small extrapolation of the sounding was necessary to reach this depth, and in addition a point is included at 40° on the upper curve measured with a somewhat different counter telescope. A discussion of the limitations in relating these counting rates to the total primary flux is given in ref. 1.

Two factors are evident from an inspection of the two curves in Fig. 2: first, of the additional particles admitted because of the decreasing cut-off by the Earth's field between 51·2° and 58·6° N. in 1955, at most one-sixth remained in 1957. The relative latitude effect has been reduced from 40 per cent to 10 per cent or less in this region. If one assigns vertical cut-off rigidities at these two latitudes (preferably on the basis of values measured directly from primary α-particles[3]) an integral number-rigidity spectrum may be computed. Assuming the form $N > P = CP^{-\gamma}$, γ has shifted from 0·36 to 0·12. Secondly, the decrease extends to much higher rigidities. The integral total spectrum above the cut-off at 51·2° geomagnetic latitude (1·7 BeV. from α-particle data) has dropped 32 per cent. Such an effect could be produced by a 'knee' appearing at about 41°, but could also be consistent with a general

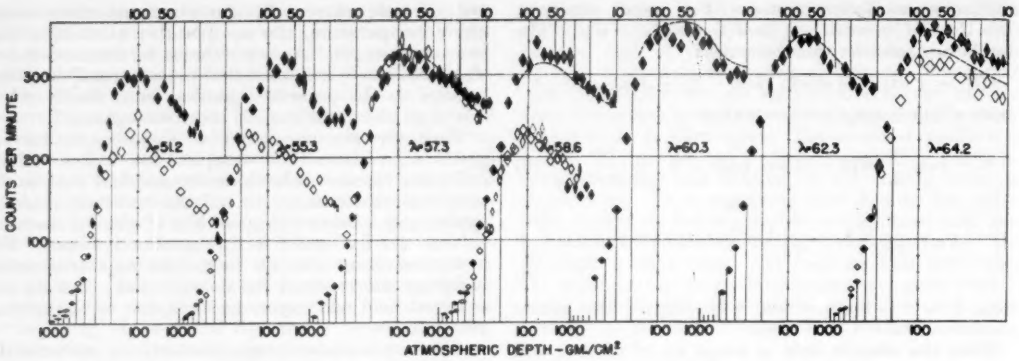

Fig. 1. Upper curves, soundings in August 1955. Lower curves, at 51·2°, 55·3° and 58·6°, soundings in June 1957

decrease of all higher rigidities, and until the total flux measurements are extended to lower latitudes, no conclusions may be drawn about the relative changes in parts of the spectrum of higher rigidity.

The tendency of the decrease to produce a higher mean energy per particle is also shown in Fig. 3, in which are compared soundings at Minneapolis (55·3° geomagnetic latitude) before and during the decrease. If we normalize the soundings at 15 gm./cm.², corresponding roughly to equal numbers of primaries, then the depressed spectrum shows a larger transition effect, occurring at somewhat greater depth (160 instead of 90 gm./cm.²), and a continued higher intensity deep into the atmosphere. Actually, the soundings measured currently at Minneapolis resemble the soundings at solar minimum measured at latitudes in the range 35°–40° geomagnetic, that is to say, characteristic of a higher average energy.

Details of the spectral changes of primary α-particles during the decrease have been measured in emulsions (see following communication by Ney *et al.*). One should note that the total spectrum in 1955 was relatively more abundantly populated below about 1·7 BeV. than the primary α-spectrum[1,2], so that the same fundamental mechanism operating on both the protons and α-particles could appear to flatten the proton spectrum relatively more than that of the α-particles.

Our present results are in general agreement with the results of Simpson *et al.*[4], who have shown that the primary spectrum as measured by neutron effects at aircraft-altitudes steepens at solar minimum and flattens at solar maximum. The increase in low-energy primaries at solar minimum has been demonstrated also by Neher[5], using integrating ionization chambers at high latitudes in balloons. The anti-correlation of general cosmic-ray intensity with solar activity discovered by Forbush[6], and at high altitude by Neher[5], is completely verified by our results, although the effect in the present solar maximum seems to be considerably greater than reported by Neher for the last cycle.

Some very approximate results on the progressive decrease during 1955–57 are available from occasional telescope flights at Minneapolis, and these are plotted in Fig. 4. The counting rate is plotted as a function of time at the four depths 20, 50, 100 and 200 gm./cm.². The downward trend began early in 1956. It recovered temporarily near the end of June 1956 (one flight only). Over the winter of 1956–57 the major part of the decrease coincided with the maximum Zurich sunspot numbers for the present cycle. The

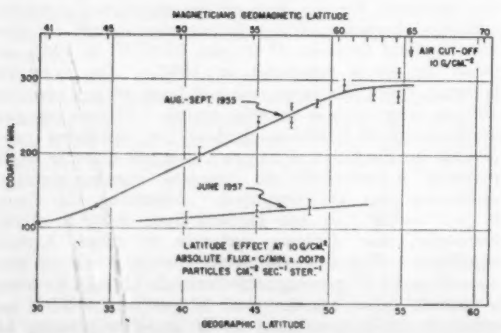

Fig. 2. The latitude effect at 10 gm./cm.² depth in 1955 and 1957

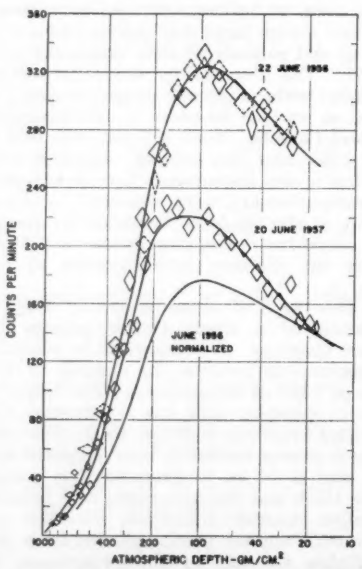

Fig. 3. Upper curves with experimental points—soundings at Minneapolis in 1956 and 1957. If the 1956 sounding is normalized to the 1957 sounding at 15 gm./cm.² (lower curve), the change to a transition effect characteristic of higher average energy is evident

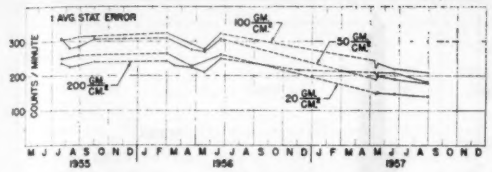
± AVG STAT ERROR
100 GM/CM²
50 GM/CM²
200 GM/CM²
20 GM/CM²
COUNTS / MINUTE
300
200
100
M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1955
1956
1957

Fig. 4. Some data on the time-progression at various atmospheric depths from telescope soundings. The decrease started in the spring of 1956, but one high sounding (June 22) was recorded. The next group of soundings was in May 1957 with the exception of one point at 200 gm./cm.² (December 1, 1956). Despite the incompleteness of the data, the crossing of the 20 and 50 gm./cm.² points over the 200 gm./cm.² curve can be seen to have occurred during the winter of 1956–57

intensity has remained low throughout the summer of 1957, and in fact the last point shown on August 31 is the lowest recorded. Fig. 4 suggests that the change in character of the primary spectrum, as shown by the steepening transition curves, occurred mostly during the winter of 1956–57, as the 20 gm./cm.² and 50 gm./cm.² levels drop below the 200 gm./cm.² level in that period.

In a previous paper[1] the latitude effect with counters was compared with measurements made by Pomerantz, and it was inferred that the latitude effect of from 52° to 69° had not changed during the decreasing portion of the last solar maximum somewhat after the peak. This, together with the present results, may be taken as evidence that the major part of the solar-cycle effect occurs near the peak in the solar cycle, and resembles a triggering mechanism rather than a proportional relationship with sunspot numbers.

The results with the ion chamber and counter at Minneapolis are shown in Fig. 5. One set of instruments was flown on October 16, 1956, and another set on April 27, 1957. The ion-chamber curves have been standardized, using a radioactive comparison source in the laboratory. The counter curves are not standardized, but the construction of the counter is held to close tolerances which should ensure geometrical normalization. The counter shows a decrease in the omni-directional flux of particles at 10 gm./cm.² of 33 per cent. The ion chamber at this level shows also closely the same decrease, and the integrated ionization in a column of the atmosphere which is proportional to the total energy influx has also decreased 33 per cent. Furthermore, in April 1957 the ion chamber shows a weak transition maximum which was absent in October 1956, indicating a shift towards higher average primary energies. These results are of a preliminary nature and will be extended following the analysis of measurements made during the course of the International Geophysical Year.

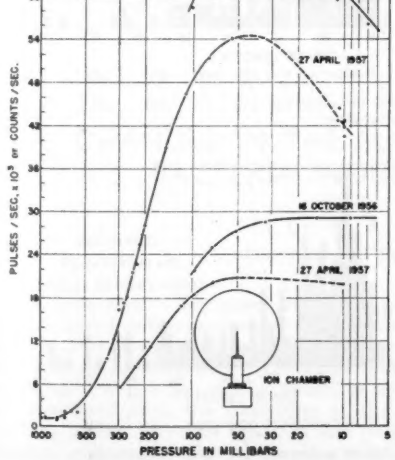

Fig. 5. Comparison, between autumn 1956 and spring 1957 at Minneapolis, of an omni-directional Geiger counter and ion chamber. The total energy influx dropped by 33 per cent in this period. Note the change in the transition curve for the ionization

We wish to acknowledge the assistance of many members of the Physics Department staff, particularly Dan MacFadden, James Stoddart and Roscoe White, for direct aid with the telescope measurements.

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Primary α-Particle Intensity at Sunspot Maximum

In the series of balloon experiments carried out by Winckler *et al.* (preceding communication), emulsion packages were included in each flight to allow the determination of the α-particle flux and energy spectrum at those times when total ionization or counting measurements showed that the total intensity had undergone a significant change. The decrease in the total intensity during the summer of 1957 was recorded in a number of flights in which satisfactory emulsion exposures were obtained. One flight made on May 17, 1957, has been analysed and is reported here.

To understand the significance of the flight of May 17 it is necessary to indicate briefly the situation that existed during sunspot minimum. A number of measurements of primary α-particles have been made at periods of low solar activity. One of these experiments was carried out in June 1954, when the solar activity was at a very low value[1]. These previous experiments gave the following results for particles incident within 45° of the zenith direction: (1) the integral flux of α-particles at high latitude was 290 ± 20 particles/m². sec. ster.; (2) the differential energy spectrum at high latitude had a broad maximum at about 300 MeV./nucleon, but did not have a sharp cut-off at any energy down at least to 150 MeV./nucleon; (3) low-energy particles were detected down to the energy limit imposed by the air above the balloon. This energy in the Saskatoon experiment was 110 MeV./nucleon.

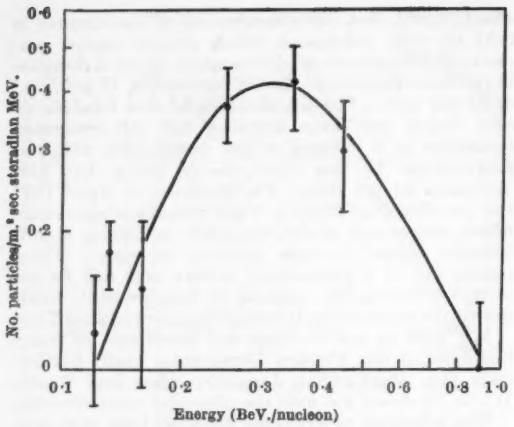

Fig. 1. Differential energy spectrum at high latitude and at sunspot minimum, Saskatoon, June 18, 1954

The energy spectrum of Fig. 1 was obtained at Saskatoon from the ionization distribution of particles observed in the emulsion stack and identified as α-particles by measurement of ionization and multiple Coulomb scattering. The ionization distributions for Saskatoon, northern Iowa, northern Missouri and Texas are shown in Fig. 2. (The data for northern Iowa, northern Missouri and Texas were obtained by P. H. Fowler, P. S. Freier and E. P. Ney and will be published in detail in *Nuovo Cimento*.) The dates of the experiments as well as the total fluxes are shown in Table 1. Within the statistics of the measurements all these distributions are consistent with the Saskatoon flux and energy spectrum, but with this spectrum cut off by the Earth's magnetic field at 300 MeV./nucleon in northern Missouri and at a much higher energy in Texas.

The ionization distribution obtained on May 17, 1957, is shown in Fig. 3. It can be seen that the spectrum is not sharply cut off, but that the total vertical flux has dropped to approximately 55 per cent of its 1954 value. Since the flux in northern Missouri in September 1956 was still consistent with the 1954 value, it appears that the change in the primary α-particles occurred at some time between September 1956 and June 1957. This is consistent with the total intensity observations of Winckler *et al.*

The significant results of the recent flight are: (1) the total flux has decreased to 157 ± 17 particles/m.² sec. ster.; this is approximately 55 per cent of last year's value; (2) the flux change has not been brought about by the imposition of a sharp cut-off; (3) low-energy particles down to the energy limit imposed by the air above are still present; (4) to account for the reduced flux both high- and low-energy particles must have been reduced in intensity.

The measurements reported here show that the large decrease in total intensity of cosmic rays at high altitude detected by Winckler *et al.* is accompanied by a decrease in the α-particle component. The α-particle data further show that the decrease occurs throughout the spectrum and that even though both low- and high-energy particles are reduced in intensity, some low-energy particles can still arrive. Some modulation mechanisms which

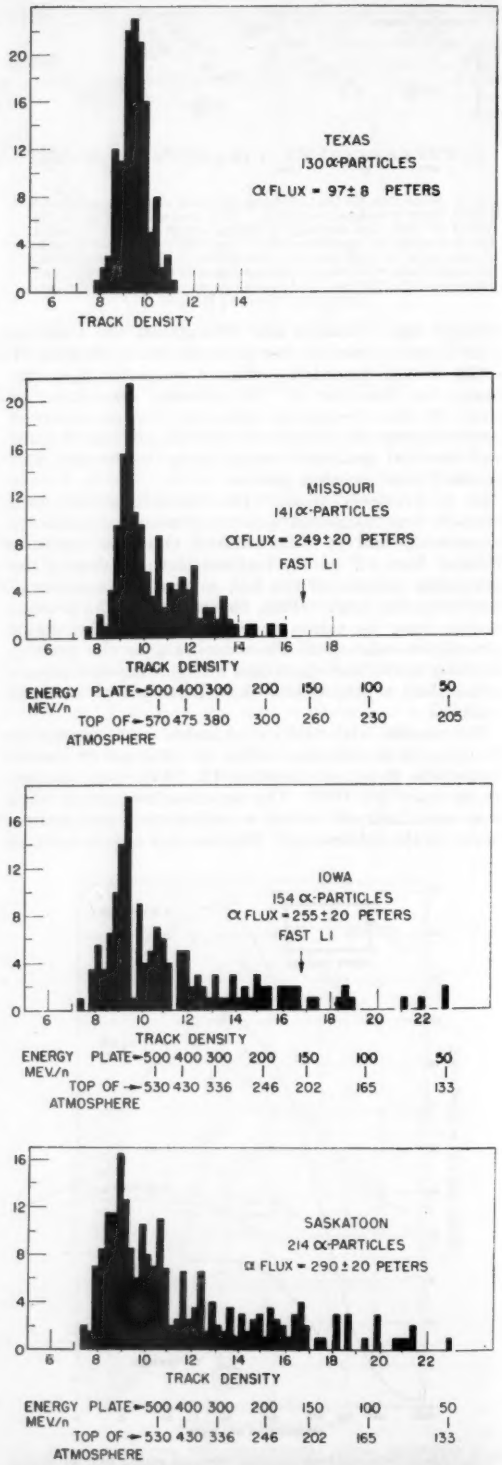

Fig. 2. Ionization distributions of α-particles at various latitudes. Ordinates represent number of particles

Table 1. Details of Flights to measure Fluxes of α-Particles

Site	Date of flight	Geographic longitude	Geographic latitude	Nominal geomagnetic latitude	Measured cut-off energy MeV./n	Cut-off appropriate to nominal geomagnetic latitude MeV./n	Integral flux corrected to top of atmosphere particles/ m.² sec. sterad.
Saskatoon, Canada	June 18, 1954	107° W.	52° 10′ N.	61°	⩽ 150	90	290 ± 20
Waukon, Iowa	May 17, 1956	91° 30′ W.	43° 50′ N.	54°	⩽ 150	330	255 ± 20
Kirksville, Missouri	Sept. 28, 1956	90° W.	40° 40′ N.	50° 30′	300 ± 20	560	249 ± 20
San Angelo, Texas	Feb. 6, 1956	101° W.	31° N.	41°	> 500	1,600	97 ± 8
Minneapolis, Minnesota	May 17, 1957	93° W.	45° N.	55°	⩽ 200	300	157 ± 17

would be allowed by the above results seem to be the following :

(1) *Time-varying magnetic fields in the solar system.* If the cut-off is magnetic in origin, the magnetic fields must be varying in time since a static magnetic field, by Liouville's theorem, would impose a sharp cut-off. E. N. Parker (private communication) has informed us that he has shown that a very high degree of symmetry is required in static magnetic fields for such fields to produce a sharp cut-off. His calculation assumes that there is not an efficient mechanism for absorption of cosmic rays to limit the time spent in the field.

(2) *Magnetic fields followed by scattering.* It is possible that static or almost static magnetic fields followed by scattering into orbits not otherwise allowed could account for the presence of both low- and high-energy particles.

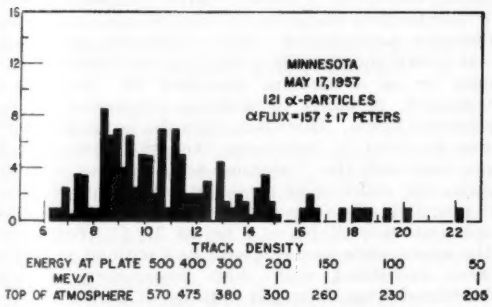

Fig. 3. Ionization distribution on May 17, 1957. Ordinate represents number of particles

(3) *Solar contribution of cosmic rays at sunspot minimum.* If the Sun were a steady source of cosmic rays, and if these cosmic rays were not able to escape from the Sun at sunspot maximum when the surface magnetic fields are high, the kind of intensity changes reported here might be observed. In order to account for the isotropy of cosmic rays at solar minimum on this hypothesis, one would have to assume that the medium through which cosmic rays pass acts to produce isotropy by some mechanism such as scattering. The solar flare event of February 23, 1956, seemed to indicate that isotropy of cosmic rays produced by the Sun can occur rapidly.

It should be pointed out that changes in the cosmic rays of the magnitude reported here must create corresponding changes in isotopes produced by cosmic rays. The consistency of cosmic-ray dating indicates, perhaps, that the intensity of cosmic rays averaged over each solar cycle does not change greatly over long periods of time. There is nothing in our results, however, to suggest this conclusion. In fact, the decrease observed seemed to occur after the Sun had reached its maximum sunspot activity, and may conceivably not be directly related to sunspot numbers or even to solar activity.

A somewhat similar but smaller change than the one reported here, apparently connected with a Forbush decrease, has been observed by McDonald[2].

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SOME CHANGES IN THE SURFACE STRUCTURE OF GRAM-NEGATIVE BACTERIA INDUCED BY PENICILLIN ACTION

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It has been known for some time that penicillin action upon micro-organisms involves a number of metabolic disturbances[1]. However, it has only been established during the past few years that some of the biochemical changes induced by penicillin are intimately associated with the formation of the surface structures of the bacterial cell. In the presence of penicillin, certain uridine nucleotides accumulated in the cells of *Staphylococcus aureus* (Park and Johnson[1]), and Park[1] found that the principal nucleotide was linked to an unidentified N-acetyl-amino-sugar and a peptide containing D-glutamic acid, L-lysine and DL-alanine. The probable significance of the accumulation of this compound became apparent when Park and Strominger[2] identified the amino-sugar as "muramic acid"[3] (an amino-sugar isolated by Strange and Dark[4], characterized by Strange[5] and Kent[6], and found as a characteristic component of the cell walls of both Gram-positive and Gram-negative bacteria[7]). The ratio of muramic acid, glutamic acid, lysine and alanine in the cell wall of *Staph. aureus* approached that found in the

Fig. 1. Electron micrograph of disintegrated spherical cells of *V. metchnikovii* obtained after 2 hr. incubation on penicillin-nutrient agar. Note presence of a 'double membrane'. Gold/palladium shadowing (× *c.* 19,000)

nucleotide, and Park and Strominger[5] have suggested that penicillin action can at least in part be explained by a block in the incorporation of the amino-sugar – peptide complex into the wall.

Investigations of cell wall composition have shown that the entire wall of many Gram-positive bacteria is composed of mucocomplex substances that are characterized by a limited variety of amino-acids together with muramic acid, glucosamine and sometimes galactosamine[7]. The walls of Gram-negative bacteria, on the other hand, are composed of both lipo-protein and mucocomplex components[8,9] (Weidel and Primosigh[8] refer to the latter component as a "lipo-polysaccharide"). Recent evidence has shown that it is the mucocomplex substance of the wall that is responsible for the structural rigidity[8,9]. Because of the duplex nature of the walls of Gram-negative bacteria, we were especially interested in finding out whether penicillin action involves a modification of one or both types of component. Lederberg[10] has recently taken the transformation of *Escherichia coli* from rod-shaped cells to spherical forms in media containing penicillin, to indicate the loss of cell wall and consequent formation of protoplasts. If this were so, then penicillin action must involve both lipo-protein and mucocomplex components of the walls of an organism such as *Esch. coli*. However, the results of the investigations we wish to report here do not support the assumption that the spherical cells (so called 'protoplasts') of Gram-negative bacteria arising during growth on media containing penicillin are analogous to the protoplasts of *Bacillus megaterium* formed by lysozyme action[11].

When thick suspensions of *Vibrio metchnikovii* were inoculated on to the surface of nutrient agar containing concentrations of penicillin (benzyl-penicillin has been used throughout) ranging from 6 to 600 μgm./ml., within 1–2 hr. at 37° C. a high proportion of the cells began to assume a spherical form. After 2–3 hr. incubation on penicillin-nutrient agar at 37° C., virtually all the bacteria were converted to spherical cells of about 1–2μ diameter. By 5 hr., the spherical cells had become enlarged to diameters of 2–3μ. For examination in the electron microscope, the 'walls' or 'membranes' were isolated from the spherical cells by disintegration and subsequent fractionation as described previously[12], or by osmotic lysis. As shown in Fig. 1, a 'double membrane' can be demonstrated in these penicillin-induced spherical forms of *V. metchnikovii*. Large spherical walls up to 4μ in diameter have been obtained after 5–24 hr. on penicillin-nutrient agar. Examination of thin sections of the spherical cells formed in the presence of penicillin has also revealed the presence of two concentric surface layers. It is now evident that these spherical cells are bounded by two surface structures, and we believe that the outer layer of the type of 'double membrane' shown in Fig. 1 represents the residual cell-wall structure deprived of its mechanically rigid component as a result of the changes effected by penicillin. The inner layer probably corresponds to the cytoplasmic membrane. The presence of a wall and cytoplasmic membrane is further strengthened by the observation that plasmolysis of the spherical cells in 5 *M* sodium chloride results in the contraction of protoplasm into a crescent-shaped body which is surrounded by a spherical wall.

For the isolation of walls in sufficient quantities for a chemical investigation of the changes occurring during the course of transformation to spherical cells, *V. metchnikovii* was grown on nutrient agar containing 600 μgm. penicillin/ml. When *Salmonella gallinarum* was grown under similar conditions on either nutrient agar or on a medium described by Medill and O'Kane[13], it failed to undergo conversion to the spherical forms. However, when the latter medium[13] was modified by increasing the salts mixture to 2 per cent and the 'Casamino-acids' (Difco) to 2 per cent, the addition of penicillin gave a quantitative conversion of *S. gallinarum* to uniformly large spherical cells (2–4μ) in 6 hr. at 37° C. Batches of the appropriate medium with and without penicillin were inoculated with thick suspensions of cells harvested from overnight cultures of the two organisms. After incubation for periods varying from 3 to 48 hr. at 37° C., the bacteria from control and penicillin media were harvested by washing from the agar surface with 0·9 per cent sodium chloride solution and the walls were isolated by disintegration and differential centrifugation[12]. Both cell-wall and 'sphere'-wall preparations were digested with trypsin to remove contaminating protein after preliminary experiments had shown that this treatment did not release any of the wall diaminopimelic acid or muramic acid. Ultra-violet absorption spectra of cell-wall and sphere-wall suspensions showed that there was no nucleic acid associated with these structures.

When paper chromatograms of hydrolysates (6 *N* hydrochloric acid, 16 hr. at 107° C.) of the wall fractions were examined, it became immediately apparent that the spherical transformation on media containing penicillin was accompanied by a reduction in the cell-wall content of both muramic acid and diaminopimelic acid. Accordingly, the course of the changes in amino-sugar content and diaminopimelic acid content of the walls of control and penicillin-induced spherical cells has been investigated. Amino-sugar was determined by the method of Rondle and Morgan[14] after hydrolysis of the preparations in

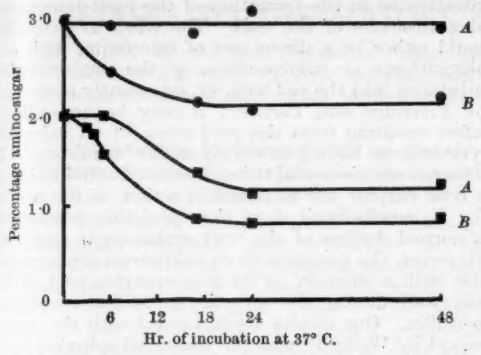

Fig. 2. Changes in the amino-sugar content of control cell walls (curves *A*) and the sphere walls isolated from the organisms grown in the presence of penicillin (curves *B*). ●—●, *S. gallinarum*; ■—■, *V. metchnikovii*

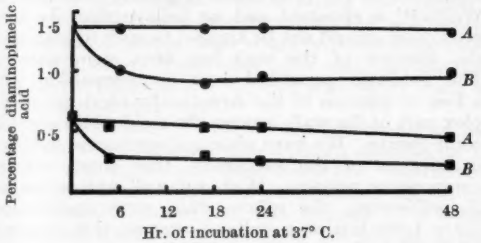

Fig. 3. Changes in the diaminopimelic acid content of control cell walls (curves *A*) and penicillin-induced sphere walls (curves *B*). ●—●, *S. gallinarum*; ■—■, *V. metchnikovii*

2 *N* hydrochloric acid for 2 hr. at 100° C. Diaminopimelic acid was estimated by the ninhydrin method described by Work[15] after preliminary separation from other amino-acids in the 6 *N* hydrochloric acid hydrolysates by chromatography on Whatman No. 1 paper with the solvent system of Hoare and Work[16]. Because of the low contents of diaminopimelic acid, large amounts of hydrolysed material had to be applied to the paper, and in order to achieve a good, clean separation it was necessary to apply the hydrolysates as bands rather than spots. Fig. 2 summarizes the results for the changes in amino-sugar content, and the decline in the diaminopimelic acid content is illustrated in Fig. 3. Although penicillin induces a rapid decrease in both the amino-sugar and diaminopimelic acid content of the sphere walls, the control walls of *V. metchnikovii* also showed a progressive loss of amino-sugar in contrast to the walls of *S. gallinarum*. This difference was not due to a difference in the media used for the two organisms, as experiments repeated with *V. metchnikovii* on the medium employed for *S. gallinarum* gave similar results. Indeed, such a loss of amino-sugar may be either the result or the cause of the 'spontaneous' spherical transformation that this organism undergoes as the culture ages.

A comparison of the composition of the control cell walls and the walls of the spherical forms is presented in Table 1. Although the amino-sugar and diaminopimelic acid contents of the walls are low, both components suffer a 30–50 per cent reduction as a result of penicillin action (Figs. 2, 3). As shown in Table 1, no such decrease occurred with the polysaccharide and lipid components. There were no qualitative differences in the major sugar constituents

Table 1. Composition of Cell Walls and Walls Isolated from Penicillin-induced Spherical Cells of *Salmonella gallinarum* and *Vibrio metchnikovii*

	Cell walls*	Sphere walls*
Per cent polysaccharide (reducing values)		
S. gallinarum	28	28
V. metchnikovii	12·3	11·4
Per cent lipid		
S. gallinarum	22	19·5
V. metchnikovii	11·2	10

* Data for parallel sets of walls isolated from 24-hr. control and penicillin agar cultures.

identified in hydrolysates of cell walls and sphere walls of both organisms (galactose, glucose, mannose and rhamnose were the principal sugars of *S. gallinarum* wall fractions, and glucose and galactose for those of *V. metchnikovii*). A variety of N-terminal amino-acids were obtained on reaction of cell walls and walls from the spherical cells of both organisms with 1-fluoro-2 : 4-dinitrobenzene[17] (a feature shared with other Gram-negative bacteria[18]), but there were no apparent qualitative differences.

The decline in both amino-sugar and diaminopimelic acid contents of the walls suggested that the part of the cell wall substance affected by penicillin is similar to the structure attacked by the bacteriophage enzyme system studied by Weidel and Primosigh[8] and to the substrate of egg-white lysozyme[9]. Lysozyme digestion of the walls of a number of Gram-negative bacteria releases most of the muramic acid and diaminopimelic acid, leaving an insoluble wall residue of reduced amino-sugar content[9]. The probability that penicillin action leads to a reduction of the mucocomplex material of the wall that may be digested with lysozyme was further strengthened by determining the changes in turbidity following incubation with lysozyme (100 μgm. crystalline egg-white lysozyme/ml.; phosphate buffer, *p*H 7; 37° C.). The reduction of turbidity of control cell walls of *S. gallinarum* and *Esch. coli* after 1 hr. incubation with lysozyme was 18 and 8 per cent, respectively; no reduction of turbidity occurred with the sphere-wall preparations. The changes in amino-sugar contents of the insoluble wall residues after lysozyme digestion of control cell walls and walls isolated from the penicillin-induced spherical forms of *V. metchnikovii* and *S. gallinarum* are presented in Table 2. These results clearly illustrate the virtual disappearance of the lysozyme 'substrate' from the sphere walls of *V. metchnikovii* and a substantial reduction in the residual amount in the sphere walls from *S. gallinarum*.

These experimental results suggest that it is the mucocomplex structure of the wall that is affected either directly or indirectly by penicillin action. It seems improbable that penicillin also blocks the production of the lipo-protein wall components, for if

Table 2. Changes in Amino-sugar Content of Control Cell Walls and Penicillin Sphere Walls after Digestion with Lysozyme

	Per cent amino-sugar			
	Control cell walls		Penicillin sphere walls	
	Untreated	Lysozyme* insoluble residues	Untreated	Lysozyme* insoluble residues
S. gallinarum	3·5	1·6	2·3	1·8
V. metchnikovii	1·8	1·5	1·5	1·5

* Preparations digested with crystalline egg-white lysozyme (100 μgm./ml.) in 0·1 *M* ammonium acetate buffer, 24 hr. incubation at 37° C. Untreated samples were incubated under identical conditions.

that were so, the pre-existing cell wall would have to be stretched by a large factor to provide a wall of the dimensions observed with the penicillin spherical forms. It is evident, however, that some cellular components continue to be synthesized in the presence of such a high concentration of penicillin (600 μgm./ml.). Indeed, substantial growth as measured by the increase in bacterial mass does occur. Using an inoculum of 3·4 mgm. dry weight bacterial plate, *V. metchnikovii* showed an increase to 18·4 mgm./plate after 3 hr. growth on nutrient agar at 37° C. and in the presence of 600 μgm. penicillin/ml. the bacterial mass rose to 13·2 mgm./plate (all estimations were performed in triplicate; owing to the osmotic fragility of the spherical cells the determinations had to be made by harvesting the bacteria from the agar surface with 0·9 per cent sodium chloride solutions and precipitating the bacterial substance by adding an equal volume of cold 10 per cent trichloroacetic acid, centrifuging the precipitates and removing residual trichloroacetic acid with ether and drying *in vacuo*; control recoveries of the inoculum suspensions showed that the errors of the method did not exceed 10–15 per cent). Thus during the transformation of *V. metchnikovii* to spherical cells of 2–3μ diameter, the increase in bacterial mass on nutrient agar containing penicillin was 72 per cent of the corresponding control (no penicillin) values. Although we have no direct proof that there is a continuance of the synthesis of cell-wall lipo-protein components, the observed increase in bacterial mass and enlargement of the spheres, together with the effects of chloramphenicol and 8-azaguanine (two substances known to inhibit a number of bacterial protein syntheses[19]), are in accord with such an event. The spherical transformation of *V. metchnikovii* on nutrient agar containing penicillin was not interfered with by the presence of chloramphenicol in concentrations of up to 200 μgm./ml. However, in the media containing penicillin and chloramphenicol (300 μgm./ml.) the spherical cells did not enlarge and their diameters did not exceed 1μ. Cells which had been allowed to become spherical on penicillin agar (2 hr. incubation at 37° C.) showed little further enlargement when transferred to nutrient agar containing both penicillin and chloramphenicol (100 μgm./ml.). In the modified medium used for *S. gallinarum*, the addition of 8-azaguanine (100 μgm./ml.) has also effected a similar limitation of the process of enlargement of the spherical cells of *V. metchnikovii* (the mean diameters of the spheres did not exceed 1μ on the medium containing penicillin and 8-azaguanine whereas the corresponding value for medium containing penicillin alone was 2–2·5μ). The reversal of the effects of 8-azaguanine demonstrated by the addition of guanine in other systems[19] has also been confirmed here. The addition of guanine (20 μgm./ml.) to the modified medium containing penicillin and 8-azaguanine (100 μgm./ml.) permitted the development of spherical cells approaching the normal size observed in the presence of penicillin alone (the observed mean diameters after 5 hr. incubation at 37° C. were: penicillin alone = 2μ; penicillin + 8-azaguanine = 0·9μ; penicillin + 8-azaguanine + guanine = 1·7μ). In a more complex medium such as nutrient agar, the addition of as much as 250 μgm. 8-azaguanine/ml. had little effect on the growth and development of spherical cells of *V. metchnikovii*.

The results of these investigations lead us to suggest that the formation of spherical cells of Gram-negative bacteria in the presence of penicillin is due to interference in the formation of the rigid mucocomplex structure of the wall. The effect of penicillin could either be a direct one of interfering with the biosynthesis or incorporation of the mucocomplex substance into the cell wall, or, as recently suggested by Prestidge and Pardee[20], it may be an indirect effect resulting from the production of an inducible lytic enzyme having an action on the 'membrane'. It does not seem essential to invoke a specific induction of a lytic enzyme due to penicillin action, as the results for *V. metchnikovii* show that penicillin accelerates a normal decline of the wall amino-sugar contents. However, the results with *S. gallinarum* are compatible with a 'dilution' of the mucocomplex part of the cell wall during the growth on media containing pencillin. Our results are in accord with the recent report by Weibull[21] that the stabilized spherical form of *Proteus vulgaris* has a reduced content of both diaminopimelic acid and amino-sugar.

That the spherical forms of these organisms are not analogous to the protoplasts originally described by Weibull[11] is apparent and we believe that the term protoplast should not be applied to such forms unless the absence of the wall has been demonstrated. The evidence presented here is compatible with a loss or dilution of the structurally rigid mucocomplex part of the wall, leaving the residual lipo-protein components. We have obtained serological evidence in support of the suggestion that some cell-wall components remain. With cell-wall anti-serum for *S. gallinarum*, the sphere walls were agglutinated (titre 1/80) but at a reduced titre to that observed with cell-wall suspensions (1/160).

We wish to thank Dr. J. Chapman (Rheumatism Research Centre, University of Manchester) for the use of the electron micrograph and for examining many of our preparations, and Mr. R. W. Horne (Cavendish Laboratory, University of Cambridge) for examining thin sections of the spherical forms. We also wish to thank Parke Davis and Co., Ltd., for a generous gift of chloramphenicol.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Temperature Measurements of Shock Waves by the Spectrum-Line Reversal Method

THE sodium-line reversal method of measuring temperature, commonly used for flames[1], has been adapted to a study of the temperature distribution behind shock waves in a conventional shock tube. In the short times available, visual or photographic methods are impracticable but, with a photomultiplier and oscillograph, time-resolved records can be made. Using a direct-current 'Pointolite' lamp as background, we have measured temperatures in the range 2,000–2,900° K. for shocks through air, nitrogen and oxygen. By studying the records at various background temperatures, the temperature of the shock-heated gases could be determined within about ± 20°, or better than 1 per cent. An extension to higher temperatures appears possible by using arc sources as background.

The shock tube was of circular section, 2½ in. bore and about 10 ft. long, with a dump chamber at the end. The light from the 'Pointolite' was focused through a window into the tube, passed out through an opposite window, and was focused by a second lens with a suitable stop on to the slit of a glass Littrow-type spectrograph giving a dispersion of 9 A./mm. A 0·18 mm. exit-slit, centred on the stronger sodium line, 5890 A., selected a portion of the spectrum 1·6 A. wide. Radiation in this region was detected by an E.M.I. 6097 *F* photomultiplier tube, and the output recorded on one beam of a Cossor 1035 Mk. II cathode-ray oscillograph. The shock speed was measured on the other beam of the oscillograph, by recording the time between signals from evaporated gold films spaced 90·3 cm. apart, the first film being either 60 cm. or 210 cm. from the diaphragm. The oscillograph was triggered, after suitable delay, by a photocell which received light as soon as the aluminium diaphragm was ruptured.

A number of records were taken on similar shocks (that is, at as nearly as possible the same shock speed) with different brightness temperature of the 'Pointolite'; the temperature of this was controlled with a variable resistor, and measured with an optical pyrometer calibrated against a standard lamp. A small correction (about 25°) was made for loss of light by reflexion at the first window. For low temperatures of the background, the sodium emission from the hot gas caused the oscillograph trace to be deflected positively as the shock passed the window, while, for a hotter background, absorption of the sodium line behind the shock front caused a negative deflexion.

The most difficult part of the problem was to disperse the sodium in the experimental gas. With flames it is customary to spray in a solution, but this is not possible at low pressure. Dusting the walls of the shock tube with sodium carbonate or sodium chloride gave strong sodium lines well behind (~50 μsec.) the shock front, but not near the front itself. We tried passing the experimental gas into the shock tube over heated sodamide (b.p. 400° C.); the sodium was indeed successfully introduced in this way, but unexplained effects were noticed; these appeared to be associated with the formation of ammonia, which might be expected to modify the composition of the gas. The method finally used was to pass the experimental gas into the shock tube through a heated quartz tube containing molten sodium chloride; this has a vapour pressure of about 1 mm. mercury at the melting point. The trace of sodium chloride presumably condensed to a fine smoke which remained in suspension for a minute or so and which was found to give sodium emission almost instantly (2–10 μsec.) as the shock wave passed through it.

Using hydrogen as driver gas, at about 7 atm., and nitrogen at 10 mm. mercury as experimental gas, the measured shock speeds corresponded quite well with those calculated[2] for the diaphragm pressure ratio and the measured temperatures were within 20° of the theoretical values calculated from the observed shock speed[2]. For air, we found that in many runs the Mach numbers were slightly higher than expected and the temperature records showed a sharp maximum, exceeding the theoretical value, some way behind the shock front. We attribute this to burning at the contact surface between air and hydrogen. Treating this as a diffusion flame between the shock-heated air and the cool expanded hydrogen, it can be shown that a rise of temperature of the order of 500° may be possible; the release of heat will also tend to produce a higher shock speed. In the region of presumably uniform flow behind the shock front, before the arrival of the burning contact zone, the measured temperatures again agree well with the calculated real-gas temperatures. Thus we obtain a number of points in the range of Mach numbers 5·8–7·3 between 2,000° and 2,725° K., in agreement with calculated temperatures.

For oxygen the effect of burning at the contact surface was even greater; a Mach number of about 6 was obtained with oxygen by using only half the diaphragm pressure ratio required for nitrogen; in the region of the contact surface, the temperature was often too high to measure (more than 2,900° K.). Fig. 1 shows a record with a hot-background source in which the sodium line is in absorption in the uniform flow region, then in emission in the burning region, followed by strong absorption again after

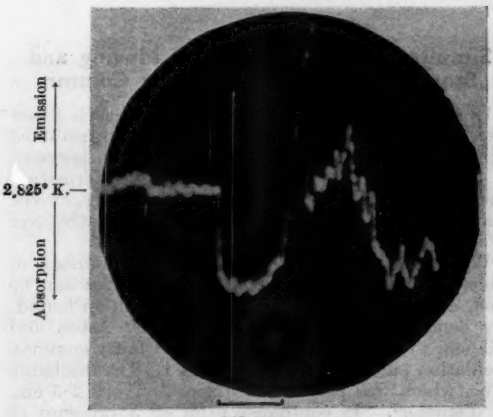

Fig. 1. Oscillograph trace of photomultiplier record from shock through oxygen; initial pressure, 10·0 mm. mercury; hydrogen driving pressure, 5,210 mm. mercury; calculated Mach number, 6·7; measured Mach number, 6·93; calculated temperature (from measured Mach number), 2,565° K.; 'Pointolite' background, 2,825° K.

the passage of the contact surface. Agreement between observed and calculated temperatures (using the measured Mach number) in the uniform flow region is again good. It was found that the region of flow behind the shock wave was shorter than calculated for a real gas; at Mach 7 in air, it was only about 50 per cent of that calculated. This is due to diffusion and eddying in the contact region and the attenuation of the shock wave.

The accuracy is limited by the noise due to statistical fluctuations in the photomultiplier signal. This is particularly important in the lower temperature-range ($\sim 2{,}000°$ K.); but, at higher temperatures with more light, the signal to noise ratio was more favourable, and other factors, such as the determination of the brightness temperature of the background, set the limit of accuracy. The calculated response time of the multiplier circuit was of the order of 5 μsec.; due to this, and the delay in excitation of the sodium, we were unable to follow the temperature course in the front itself.

In the early work we attempted to measure the shock speed with ionization probes, as well as with the gold-film gauges. With sodium introduced as a dust on the walls, it was noticeable that the ionization followed the light emission and lagged behind the front, as detected by the gold films. It seems that ionization probes are unlikely to be reliable for detecting the shock front in this temperature-range (2,000–2,900° K.), where gaseous ionization is not to be expected and the observed ionization is due to easily ionized metallic impurities scrubbed from the walls after the shock front has passed.

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Simultaneous Occurrence of Moving and Standing Waves in a Positive Column

In the literature on moving striations—such as are seen in commercial neon signs—it has been mentioned repeatedly that stationary striations may be present at the same time[1]. Not much definite information has, however, been published about the latter, except that they are most prominent near the negative end of the positive column.

We have recently obtained a large number of photographs in which these standing waves can be seen, during the course of an investigation on boundary conditions in moving striations by Aston and Kikuchi's rotating mirror method[2]. A fairly common oscillation pattern is shown in Fig. 1. The discharge tube, which was mounted horizontally, was 2·5 cm. in diameter[3]. It contained neon at a pressure of 3·9 mm. of mercury, and was passing a current of 30 m.amp. The axis of the mirror between the tube and camera was also horizontal, so that any horizontal section of the photograph gives the appearance of the discharge along the tube at a particular

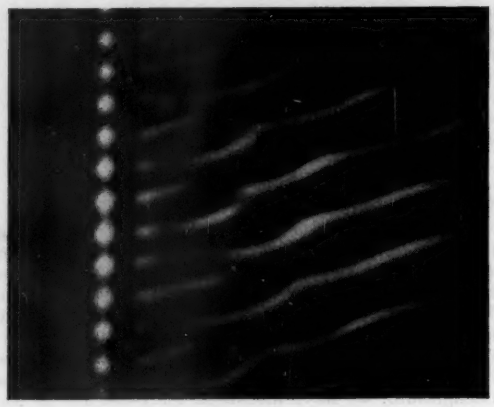

Fig. 1

instant. Time increases downwards in Fig. 1, the distance from top to bottom corresponding to $3{\cdot}2 \times 10^{-3}$ sec. The length of tube included horizontally is 19·5 cm.; the cathode was 1 cm. farther to the left, and the anode 1·2 cm. to the right. The dark space on the left is the Faraday dark space.

The inclined bright lines at the right are striations moving away from the anode with a speed of approximately $1{\cdot}6 \times 10^4$ cm./sec., and a frequency of 2190 sec.$^{-1}$. At the edge of the Faraday dark space there is a standing wave of luminosity, with double the frequency of the moving waves. The appearance here, and immediately to the right, is roughly what would be obtained by superposing an undamped wave moving towards the negative end of the column and a damped wave moving in the opposite direction. The latter might be the former reflected at the Faraday dark space by an increase in electron concentration or an axial concentration gradient. This explanation does not, however, account for all the detail of this and other photographs, including in this instance the frequency doubling. The negative end of the column where standing waves appear also seems to act in some respects as a separate unit of the discharge. This may be because the oscillations have large amplitude, and are almost certainly non-linear.

With the type of discharge studied, frequency doubling, with the accompanying branching of the striations, was not observed for any current at a pressure of 2 mm. of mercury, but it was present for all currents at 5 mm. of mercury. At 3 mm. and 4 mm. of mercury, branching appeared for currents greater than 26 and 22 m.amp. respectively. For larger currents, after branching with frequency doubling had occurred, the length of the branched region decreased rapidly with increasing current, giving a much simpler pattern. The standing wave at the left tended to become continuous and give an unbroken vertical streak in the photograph.

No fluctuations in luminosity of the negative glow comparable with those in the positive column have been found, except when the discharge was passing to the rear of the cathode. Whenever conditions were suitable for viewing the anode glow, however, this was seen to be oscillating with a frequency several times that of the striations, and to be generating the moving striations in the manner described by Takamine *et al.*[4], the amplitude of oscillation growing until the spot peeled off.

The standing waves described in this communication are different from the well-known stationary striations which can form in molecular gases passing smaller currents; the latter have a different shape and electrical properties[5], and, it is believed, can occur without oscillation[6].

We wish to thank Prof. N. L. Oleson for his interest in this work.

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Effect of Pressure on Burning Velocity of Nitric Oxide Flames

The burning velocities of stoichiometric mixtures of hydrogen and nitric oxide, and of methane and nitric oxide have been measured by the Bunsen burner method over the pressure-range 0·2–40 atm. abs. An averaged burning velocity was obtained from the measurement of the total volume flow of gas and the total area of the flame front. The experimental technique was essentially that of Diederichsen and Wolfhard[1].

Measurements were made at a constant Reynolds number[1,2] for each of the hydrogen and methane systems. Moreover, the diameter of the burner was varied approximately inversely as the pressure, so as to maintain as nearly as possible the same flame-shape at all pressures. In this way the relative contributions of those parts of the Bunsen-type flame, which are recognized to be respectively greater or less than the mean value of the burning velocity, can be kept constant. The measurements should then give a true indication of the dependence of the burning velocity upon pressure.

The results obtained in this investigation are recorded in Table 1, and indicate that burning velocity is independent of pressure within the limits of experimental error in the range 1–40 atm. The value of the burning velocity of the hydrogen/nitric oxide flame at atmospheric pressure is substantially greater than those reported in the literature, namely, 30 cm./sec. (ref. 3) and 22 cm./sec. (ref. 4). The lack of a significant dependence on pressure in the results of this investigation is at variance with the findings of Rozlovskii[4], who reports that the burning velocity of a nearly stoichiometric hydrogen/nitric oxide flame is independent of pressure in the range 1·8–4 atm. abs., but increases with pressure p according to a $p^{0.482}$ law for p between 4 and 19 atm. abs.

The hydrogen/nitric oxide and methane/nitric oxide systems may be compared with the methane/oxygen system discussed by Diederichsen and Wolfhard[1]. In each case the flame temperature varies markedly with pressure whereas the concentrations of hydroxyl radicals, and hydrogen and oxygen atoms, vary only slightly with pressure. None of these systems shows a significant variation of burning velocity with pressure.

Table 1

Hydrogen–nitric oxide		Methane–nitric oxide	
Pressure (atm. abs.)	Burning velocity (cm./sec.)	Pressure (atm. abs.)	Burning velocity (cm./sec.)
0 32	36	0·23	29
1·00	49	0·98	41
3·0	63	3·0	42
6·1	63	6·5	42
9·8	63	13·9	37
10·5	60	27·6	34
21·4	54		
29·9	53		
40·5	60		

It has been suggested[5] that the mechanism of the hydrogen/nitric oxide flame differs from that of the methane/nitric oxide flame and is, in fact, governed by the bimolecular decomposition of nitric oxide as the rate-determining step. However, such a proposed difference in mechanism is not reflected by any significant difference in the dependence on pressure or magnitude of the burning velocity of the hydrogen/nitric oxide flame as compared to the methane/nitric oxide flame.

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Role of Photons in Argon–Alcohol Counters

It is well known that in a Geiger discharge some of the avalanche photons, presumably argon resonance photons[1], are strongly absorbed in the quenching gas and are responsible for the discharge propagation in a narrow zone around the anode[2]. On the other hand photons of greater wave-length are also produced; these can release photo-electrons out of the cathode with subsequent production of secondary avalanches[3,4]. Some authors ascribe a dominant role in the discharge-spreading mechanism to the latter photons. In this assumption the velocity of discharge propagation would be determined by the photo-electric effect at the cathode and not by the photo-ionization of the gas near the anode, as is usually admitted. This contradicts the following experiment.

We used the counter sketched in Fig. 1. It has three aluminium cathodes A, B and C, diameter 1·5 cm., with lengths 3 cm., 10 cm. and 3 cm. respectively, held at a mutual distance of 0·2 mm. by suitable glass tubes. The anode is a central molybdenum wire, diameter 0·08 mm. Cathode A has a mica window (3 mgm./cm.^{2}). The filling gas is argon (9 cm. mercury) and alcohol vapour (1 cm. mercury).

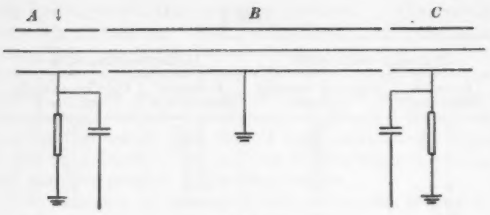

Fig. 1

Discharges are initiated in A by α-particles from a polonium source. At and above the starting voltage (about 820 V.) the discharge spreads from A to C. The voltage pulse of cathode A triggers the time base of an oscilloscope, to the vertical deflexion plates of which the voltage pulse of cathode C is applied. The time interval needed by the discharge to proceed from A to C is measured on the oscilloscope screen.

Figs. 2 and 3 are records of about one hundred pulses, at 830 and 860 V. anode voltage respectively. Apart from a small statistical fluctuation, which decreases with increasing overvoltage, the measured propagation time is 2·6 μsec. at 830 V., 1·5 μsec. at 860 V., the distance between the time marks corresponding to 0·4 μsec.

Fig. 4 has been recorded under identical conditions (number of pulses, overvoltage, sensibility of the oscilloscope, velocity of the time base) as Fig. 3, except that here the discharges were initiated by ultra-violet photons proceeding through the mica window from an external light source. One can see that the amplitude of the C pulse is the same as in Fig. 3, as it should be, that the maximum time interval between A and C pulses is the same in both cases, and that this time interval now straggles considerably. The record indeed shows C pulses generated after as well as before the corresponding A pulse triggers the time base. In the case of Fig. 4 the initiating avalanche is created by a photo-electron released from the cathode by an incoming photon, as is well known. The evidence of the present experiment is that, before the release, the photon may have suffered several reflexions against the cathode, so that the initiating avalanche is created at a random place in either section A, B or C. From this place the usual discharge then proceeds to both A and C. As a result the time interval elapsing between corresponding A and C pulses is random, with a maximum value equal to that found in Fig. 3. That the major number of intervals is still of the order of 1·5 μsec., as in Fig. 3, can easily be accounted for.

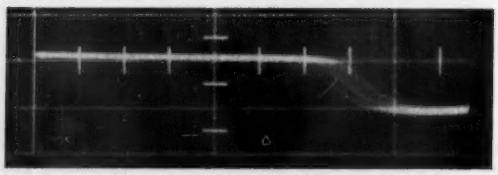

Fig. 2

Fig. 3

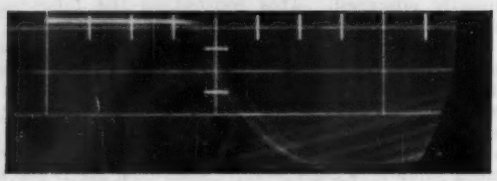

Fig. 4

This seems to rule out the possibility that soft avalanche photons may take any dominant role in the propagation mechanism. If indeed they were involved in the discharges of Figs. 2 and 3, they would be subjected to the same occasional reflexions against the cathode as are the external photons of Fig. 4, since both radiations have about the same energy. As a result the straggling of the propagation time intervals, particularly in Fig. 3, should have been comparable to the one observed in Fig. 4. This is obviously not the case. We should add that in long counters (>50 cm.) abnormally short propagation times have indeed occasionally been observed[5]. They are probably related to exceptional interventions of soft avalanche photons.

That the statistical fluctuation of propagation intervals for α-pulses decreases with increasing overvoltage as in Figs. 2 and 3 is to be expected, since the number of hard photons in any individual avalanche increases correspondingly.

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Cavitation and the Solution of Gases in Liquids

When water is flowing through a conduit or past an obstacle it is commonly stated that a cavity will be formed wherever the hydrostatic pressure falls to the appropriate value of the water-vapour pressure or, if intense sound waves are being sent through the water, when the pressure in the negative part of the cycle drops to this value. The threshold pressure for cavitation may also be calculated, apart from the question of the motion of the liquid, from the work required to tear the molecules apart. This would require a tension of about 1,000 atm., whereas experiments by Temperley and Chambers[1] and others show that water may be fractured by tensions of 10–30 atm. Additional mechanisms for cavitation have therefore been suggested.

Thus small motes or air bubbles in the water may act as nuclei around which the cavities can grow when the pressure conditions are right[2]. Whether solid inclusions *per se* can act as nuclei is now dubious.

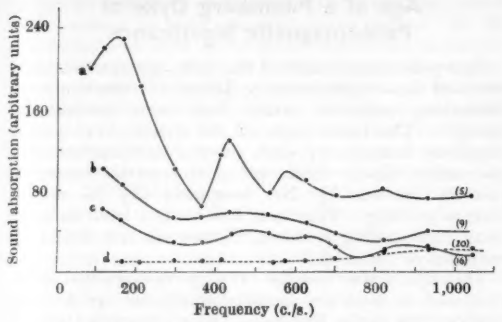

Fig. 1. Variation of sound absorption with frequency in tap water: (*a*) on pouring; (*b*) after ½ hr.; (*c*) after 1 hr.; (*d*) after applying 5,000 lb./in.² for 1 min.

The action by which water, irradiated by an ultrasonic transducer at a little below the power required to produce cavitation, suddenly becomes filled with a cloud of cavitation bubbles on adding a pinch of salt[2] or other solid has been proved to be due to occlusions of air carried in with the salt, although it is true that in the absence of air bubbles sharp roughnesses on the wall of a conduit may induce cavitation. There remain three relevant facts with regard to the action of such air nuclei: (1) water de-aerated by boiling and cooling is much more difficult to cavitate than fresh tap water; (2) it is more difficult to set up cavitation after standing for several hours; (3) application of hydrostatic pressures of several hundred lb./in.² to tap water also makes it difficult to set up cavitation. On the nucleation principle one would explain these effects thus: tap water contains a quantity of tiny air bubbles which on boiling or prolonged standing disappear; pressure drives them into solution.

We have investigated these effects and counted the numbers and estimated the mean size of such nuclei using two techniques, one acoustical and one optical[4]. Briefly, the first of these involves sending a pulse of sound into a flask containing the sample and picking up the signal as the sound reverberates within the vessel. After allowing for the effects of the vessel, the decay time of the sound may be related to the absorption of the sound in the water. If the frequency chosen happens to be near the natural frequencies of some air bubbles, they resonantly absorb the sound. It is then possible to relate the absorption curve for a range of frequencies to the size of the air nuclei present. Fig. 1 shows that in the sample of water chosen there were originally many bubbles having diameters between 8 and 40μ (natural frequencies 825 and 165 kc./sec.): these disappear on standing or on applying pressure. The numbers attached to the curves show the relative threshold tensions—in arbitrary units—required for cavitation.

There is always a threshold—usually higher than that due to air nuclei—at which water, free from all air nuclei, will form cavities of its own vapour, unmixed with air. These 'vaporous cavities' are distinguished physically by the fact that they usually form at protruberances on the walls or other solid boundary and tend to collapse on release of the tension which caused them. If the ear or a hydrophone be placed in the water, the inception of vaporous cavitation can be detected as a loud tearing sound, whereas the other type is a gentle musical sound like the noise of a brook on a shallow bed. Pressurization raises both these thresholds.

Much may be learnt about the fundamental aspects by repeating these experiments on organic liquids. We have used acetone, benzene, toluene and carbon tetrachloride among others. Even after considerable aeration, we have been unable to detect the presence of nuclei in them by either of our techniques: only vaporous cavitation originating at the walls, or in some cases no cavitation at all, could be induced within the power limits of our ultrasonic transducer.

These results with organic liquids receive—from the point of view of their being due to absence of nuclei—confirmation from two other sources. Pattle[5] produced bubbles of gas from a glass tip immersed in a liquid, and by photographing them as they rose determined the rate at which they vanished as the gas dissolved. Whereas bubbles of 50μ or less could only be formed with difficulty in oil, and in clean de-aerated water disappeared within 3 min., if the water contained protein they often reached a limiting size at which they became stable. At the other extreme, a 50-μ bubble in carbon tetrachloride had a life-time of only 15 sec. Following a suggestion of Fox and Herzfeld[6], the protein may act as a semi-permeable barrier to the outward diffusion of air from the bubble.

Our results have an important bearing on the solution of gases in liquids. Data on this subject are meagre and qualitative. Metschl[7] states that acetone and benzene can be made to hold seven times and carbon tetrachloride eleven times as much oxygen as can water at atmospheric pressure. It has been usual to measure dissolved oxygen by chemical analysis (Winkler's method) or by removing all the dissolved gas by spraying into a vacuum (van Slyke's method) as we have done. Both these methods give the total gas content. When it is desired to measure only the gas in true solution, acoustic experiments of the type mentioned must be made, and the total estimated volume of the nuclei subtracted from the total gas content.

We therefore conclude—vaporous cavitation aside—that the breakdown of a liquid in a pump, propeller or other hydraulic machine, with consequent loss of efficiency and possibility of erosion, is to be ascribed to free nuclei and that the engineer need not worry about gas in solution.

On the other hand, if the liquid contains protein a protective skin may be formed around the nucleus, as the experiments of Pattle suggest. A similar idea has been put forward by Moore[8] to explain the stability of foam at the sea surface, and we have confirmed this by noting that cavitation can be set up in a sample of sea water taken near the surface as readily as in fresh tap water.

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March 12.

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Dynamic and Static Elasticities of Solids

Measurement of the velocity of sound forms a convenient way of measuring elasticities. In a thin rod the longitudinal velocity is governed by Young's modulus E and the torsional velocity by the rigidity modulus n. For solids the difference between dynamic and static values arises mainly from the specific heats. Thus the ratio of the values of E will be equal to the ratio of the specific heats, γ. For torsional strains there is no change in volume, and it is assumed that there will be no difference in the values of n. On the basis of these two assumptions, the expression relating Poisson's ratio σ to the velocity measurements will be $\frac{\gamma E}{n} = \left(\frac{v_L}{v_T}\right)^2 = 2\gamma(1 + \sigma)$. The values of E, n and σ should approximate closely to static values, although deviations arising from frequency-sensitive elastic effects are to be expected.

The pulse method of measuring the longitudinal velocity described earlier[1] has been extended to torsional measurements. It enables both velocities to be measured for the same specimen under precisely the same conditions. A check of the expression given above can therefore be carried out.

The pulses are launched and received by coils on a magnetostrictive tube. For longitudinal pulses the tube is polarized longitudinally, for torsional pulses it is polarized circumferentially. A matching unit passes the pulse to a rod of the material to be measured. Two echoes are received back from the specimen, one from the end and the other from a machined shoulder of a suitable shape to give reasonably sized echoes for both types of pulse. The time interval between the two echoes gives the velocity.

In testing the method it was found that a graph of time interval against shoulder to end distance, obtained by cutting pieces off the specimen, gave a straight line which did not quite go through the origin. The error, of the order of one quarter of the pulse length, was eliminated by taking the velocity from the slope of the line.

The results on specimens chosen for a wide range in values of σ and γ are shown in Table 1. The good agreement between the observed and text-book values of σ shows the value and accuracy of the expression for the analysis of dynamic measurements.

Table 1

Solid	σ*	γ*	v_L (m./s.)	v_T (m./s.)	σ
Aluminium	0·337	1·049	5,164	3,081	0·339
Copper	0·334	1·028	3,723	2,234	0·350
Lead	0·446	1·072	1,422	803·4	0·461
Fused quartz	(0·17)	(1·001)	5,762	3,780	0·160

* Values from ref. 2

Measurements so far carried out do not show any great variation of σ with temperature or physical condition of the specimens.

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Age of a Pilansberg Dyke of Palæomagnetic Significance

The palæomagnetism of the dyke system radiating outward in a south-easterly direction from the large Pilansberg eruptive centre has been studied by Gough[1]. The basic parts of the dykes show a high magnetic consistency and, on the assumption of a geocentric dipole field, place the north magnetic pole in latitude 7½° N., longitude 47½° E. at the time of cooling. This time has always been inferred from surrounding systems, themselves not dated by radioactive methods.

The dykes are mainly of very fine-grained basic rock and as such are unsatisfactory for age-determination, but in the Robinson Dyke (Gough's Dyke *C*) a centre felspathic zone with development of biotite occurs. This dyke was sampled at levels No. 61 and 62 in the Robinson Deep Mine. These levels are at a depth of approximately 8,000 ft., and 160 ft. apart vertically. The palæomagnetic measurements at level 61 show a centre zone of low-intensity, unstable, felspathic material and the sample used was taken from this zone. At level 62, although the felspathic zone is developed, the magnetic measurements show stability through the full width of the dyke. The sample chosen was from the centre felspathic zone. The felspars at both levels were cloudy and altered but at level 62 the biotite, itself a late magmatic alteration product from hornblende, showed comparatively little hydrothermal alteration to chlorite. At level 61 most of the biotite had been altered to chlorite. It was not possible to separate pure samples of biotite/chlorite from either level, but, after magnetic and vibrating-table separations, samples enriched from the initial concentration of ½–1 per cent biotite/chlorite were obtained. These were used for the age determinations reported in Table 1.

Table 1

Sample	Percentage biotite/chlorite	Strontium-87	Age $\times 10^{-6}$ yr. ($T_{1/2} = 5{\cdot}0 \times 10^{10}$ yr.)
P.61	30–35	0·0796	1,340 ± 290
P.62a	20–25	0·0790	1,230 ± 240
P.62b	55–60	0·1390	1,290 ± 140

The sample numbers refer to levels 61 and 62, and *a* and *b* distinguish between two different separations from the same hand sample. The errors quoted are 99 per cent confidence limits and the most probable age is 1,290 ± 180 million years. The material is essentially poor for age determination in that the rock shows alteration and, even in the biotite-enriched separations made, the abundance of the radiogenic isotope, strontium-87, was not high. This limits the accuracy with which the age can be determined. The abundance of this isotope at the time of crystallization was found to be 0·0703 from measurements on the total rock, which has a very high ratio of strontium to rubidium.

The magnetic instability of the felspathic centre zone of level 61 and the alterations observed in the minerals of the rock weaken the argument that the ages determined are the true ages of intrusion. These ages will only be meaningful if the alteration took place within a time small compared with age after the rock had crystallized. Two arguments may be advanced to show that this was the case. First, the concordant ages measured on samples from level

62 are on fractions of the same hand sample, which differ widely in their mineral compositions. If the alteration was such as to cause significant deviation from the true age, it must further be postulated that the alteration affected the concentrations of rubidium and strontium in the different minerals in the same proportions. This is thought to be unlikely. Secondly, the alterations at levels 61 and 62 are markedly different in degree, and it would be unlikely that the balance of rubidium and strontium would remain the same in both. If the alteration took place in the immediately post-intrusion period, 'true' and 'measured' ages would be coincident for both samples.

The age reported here differs widely from that inferred by Cooke[2], but does not involve any change in the relationship of the dykes with surrounding formations. Cooke's estimate was based on the relation of the Waterberg to the Bushveld igneous complex, which was thought to be late pre-Cambrian. The Bushveld igneous complex has been shown[3] to be 1,920 million years old, and a corresponding expansion of the time-scale involving the dyke system becomes possible. The consequences in stratigraphy of these determinations and greater detail of the determinations will be presented elsewhere.

I wish to thank Mr. C. B. van Niekerk of the South African National Physical Research Laboratory for collecting the samples and undertaking the arduous and lengthy separations necessary; Dr. D. I. Gough for helpful discussions on the palæomagnetic measurements; and Dr. H. L. Allsopp for assistance in the mass spectrometry. My thanks are also due to the Carnegie Institution of Washington and the Nuffield Board of Trustees, for financial support.

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Annual Rainfall Distribution in East Africa

It has been a general practice over the past few years to assume that the annual rainfall amounts recorded at stations in East Africa follow a normal distribution law[1,2]; but this assumption has not been based on a detailed analysis of all the long-period data. The reason for this may be that an analysis of the station with the longest record (Padua, Italy, 225 years) has shown the distribution to be not significantly different from normal and so it was thought that this should hold true for other stations.

An initial analysis of thirty stations in East Africa, typical of the geographical and climatic zones, has been completed. This is the first stage of a full investigation of the 240 stations available with more than thirty years records. So far, it seems that areas of rainfall not normally distributed tend to be located in the west of the territory and the drier areas, but two exceptions to this are Nairobi (Kenya) and Gulu (north-east Uganda). Assuming the distribution to be normal, half the stations received one annual fall greater than expected, while some recorded amounts that would have been forecast only once in 1,000–7,000 years. In all, 21 of the 30 stations proved to be not significantly different from normal, one being doubtful and eight not normal. There were three stations, Mbarara (Uganda), Fort Portal (Uganda) and Dodoma (Tanganyika), with a distribution not significantly different from normal when the outstandingly high year was omitted, so that normal limits were applicable, except at high values. Of the five stations remaining, four fitted a log-normal distribution, leaving only Nairobi non-defined. In view of this discrepancy another station about one mile away from the Nairobi site was examined, but this followed an identical pattern.

Much difficulty has been experienced while testing the stations for normality as most of them have only some 40–50 years records, thus making full moment-fitting inadvisable. The tests used are Cornu's criterion, skewness limits and kurtosis limits, but with such small numbers no test is really foolproof.

It has become clear from this preliminary analysis of East African stations that it is not sound to assume normality of distribution without first testing the data for the station. Even nearby sites cannot be used with certainty, for Nairobi and Kabete, only 8 miles apart, show normal and not-normal distribution respectively. This fact makes prognostication based on normality rather unreliable, but it is hoped that some pattern will evolve when the work is completed.

The final, full investigation of the 240 stations will contain, as well as normality tests, the trends of the 30-year moving mean and the reliability of sampling certain periods of observations.

I am indebted to the director of the East African Meteorological Department for permission to publish this initial report.

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Control of Surface Concentration in the Diffusion of Phosphorus in Silicon

A problem in the production of transistor structures by diffusion is to control the surface concentration at a required level (about 5×10^{18} atoms/cm.[3] in a typical case). Diffusion of phosphorus by conventional methods produces concentrations between 10^{20}–10^{21} atoms/cm.[3] due to the high solubility of the phosphorus at the diffusion temperatures[1]. A method of obtaining desired values of surface concentration over the range 5×10^{16} to 5×10^{18} atoms/cm.[3] by controlling the phosphorus vapour pressure has been successfully evolved.

Diffusion is carried out in a closed evacuated tube, one end of which, containing the silicon slices, is held in a diffusion furnace, the other, containing pure distilled yellow phosphorus, being maintained at temperatures in the range $-30°$ C. to $+35°$ C. controlled to $\pm$ 0·5° C. The silicon slices, doped with boron to 1 ohm.cm. resistivity (a value chosen for transistor application), are lapped on 'Unirundum 85' powder, and then etched to a mirror finish with a mixture of nitric acid/hydrofluoric acid (80/20 per cent).

The hot part of the system, including the silicon slices, is thoroughly outgassed by baking up to 700° C. before sealing off. After diffusion the surface concentration is determined by four probe-conduct-

Table 1

Phosphorus temperature (° K.)	Phosphorus pressure (mm. mercury)	Diffusion temperature (° K.)	Diffusion time (hr.)	Surface concentration (atoms/cm.³)	S/K (sec.)
308	10^{-1}	1,473	12	$4{\cdot}5 \times 10^{18}$	0·28
293	$3{\cdot}5 \times 10^{-2}$	1,473	12	$1{\cdot}7 \times 10^{18}$	0·30
273	$6{\cdot}0 \times 10^{-3}$	1,473	12	$5{\cdot}0 \times 10^{17}$	0·5
253	$9{\cdot}0 \times 10^{-4}$	1,473	8	$1{\cdot}5 \times 10^{17}$	1·0
245	$3{\cdot}5 \times 10^{-4}$	1,473	12	$6{\cdot}0 \times 10^{16}$	1·05
233	$7{\cdot}0 \times 10^{-5}$	1,473	10	$< 10^{16}$	—
293	$3{\cdot}5 \times 10^{-2}$	1,473	17	$2{\cdot}0 \times 10^{18}$	—
293	$3{\cdot}5 \times 10^{-2}$	1,473	24	$1{\cdot}5 \times 10^{18}$	—
293	$3{\cdot}5 \times 10^{-2}$	1,373	44	$4{\cdot}0 \times 10^{18}$	—

ivity measurements, a technique described by Fuller and Ditzenberger[1].

Table 1 gives the results obtained in a series of experiments. Values for the vapour pressure of phosphorus are taken from MacRae and Vanvoorhis[2]. The last column gives values of the ratio S/K, where S is defined as the sticking coefficient and K a rate constant for re-evaporation of phosphorus atoms from the surface, following the work on the out-diffusion of antimony from germanium described by Smits and Miller[3]. S/K is proportional to the ratio surface concentration/phosphorus pressure and should be constant. These values show a dependence on pressure.

Surface concentration and vapour pressure of phosphorus are plotted against temperature in Fig. 1. The results show that the surface concentration follows very closely the vapour pressure of phosphorus, but within the ranges investigated is not markedly dependent on the diffusion temperature or the time. This factor allows flexibility for the variation in junction depth for a given surface concentration. However, attempts to detect lower surface concentration at lower pressures using silicon of higher resistivity have not so far been successful; this is not yet understood. A detailed description of these experiments will be published elsewhere.

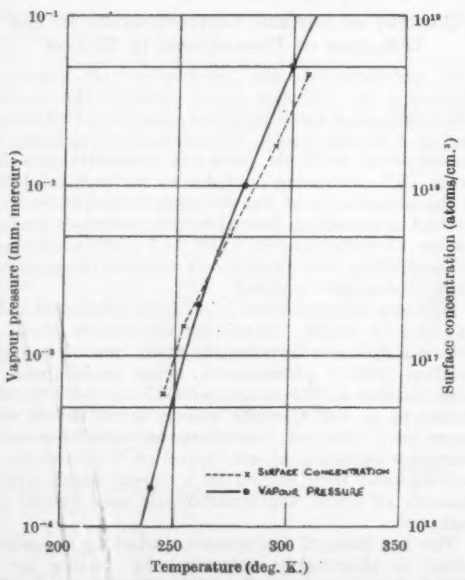

Fig. 1. Plot of vapour pressure of phosphorus and surface concentration against temperature

I wish to thank the Admiralty for permission to publish this communication.

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Magnetic Constriction in Simple Diodes

A piece of classical electronic physics is the study of one-dimensional space-charge-limited currents between infinite planes, co-axial cylinders and concentric spheres[1–3]. Recently, this has been extended to the case of relativistic electron speeds[4]. Examination of the validity of the extension has revealed that not only in the relativistic but also in the classical cases, such flows are—even in principle—impossible, and that certain restrictions on the size of the cathode are necessary for their approximate realization.

Consider, for example, the non-relativistic flow between two infinite planes. Let the Child–Langmuir uniform current density be J. The current in a cylindrical tube of flow of radius r is $\pi r^2 J$. By Ampère's circuital law, there will be on the surface of the tube a transverse tangential component of magnetic field, H, given by:

$$2\pi r H = \pi r^2 J$$

Hence $H = \frac{1}{2} r J$ becomes indefinitely large as r increases. But this is impossible for the uniform beam of infinite cross-section postulated, as in such a beam the value of H—if finite at all—must have the same value at all points in a plane normal to the flow. Hence Child–Langmuir flow is impossible.

What this means physically is that if one starts with a thin beam and then broadens it, the magnetic attraction of the current filaments increases without limit and must pinch in the beam, as in the well-known effect in gas discharges, so destroying the uniformity and parallelism of the flow. I have (cf. Meltzer[5]) estimated for relativistic as well as non-relativistic beams what restriction must be placed on the size of the cathode for parallel flow to be approximately realizable. Typical results are: the ratio of radius to anode–cathode spacing must be considerably less than 29, 5·6 and 1·1, for diodes in which the maximum kinetic energy of the electrons is respectively one-tenth, equal to and ten times their rest-energy.

Similar arguments show that Langmuir radial flow between cylinders and spheres is in principle impossible, though the argument for cylinders is a little different from that for planes and spheres.

One naturally inquires what the pattern of stable flow in such systems would be. This is well worth experimental investigation; very probably one, two or more constricted beams from the cathode will be found, depending on the departures from perfect symmetry necessitated in a realizable physical system with return path for the current. If this proved to be so, even for non-relativistic speeds, some of the curious structural features found in electron beams, such as the discrete-pencil structure found in a quite conventional electrostatic system by

Klemperer[6], and those observed in electromagnetic systems by Webster[7] and Cutler[8], might find their explanation in this simple self-magnetic effect.

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A New Concept of the Transformation Sequence of Kaolinite to Mullite

MANY solid-state reactions involving oxide systems take place by re-organization of cations within a framework of oxygen ions and the rate of the reaction is controlled by ion diffusion rather than by nucleation and grain growth processes. This general concept has been well illustrated by recent work of Bernal *et al.*[1] on oriented transformations of iron oxides and hydroxides, and of Steadman and Youell[2] on the thermal transformation of an iron silicate of layer-lattice type.

Single crystals of kaolinite, 0·1–0·2 mm. in size, have facilitated an X-ray study of the progressive re-organization of the kaolinite layer-lattice structure, through an intermediate cubic spinel-type phase, finally to the chain-like structure of mullite. A new interpretation of the spinel-type phase provides the key to the understanding of the whole process. Hitherto this phase has been called γ-alumina, though the evidence never went beyond demonstrating a spinel-type structure, and this hypothesis has given rise to many difficulties. In particular, there is no evidence for the large amount of silica which must be discarded. We believe that a defect silicon-spinel provides a more convincing explanation for all aspects of the transformation. This idea has been put forward simultaneously by Steadman and Youell[2] and by us[3]. The single-crystal studies show that the spinel phase has a high degree of orientation (Fig. 1) with respect to the original kaolinite crystal,

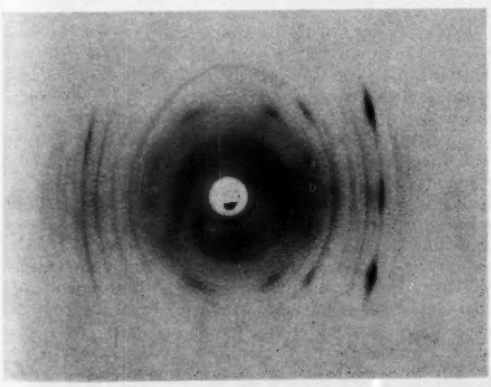

Fig. 1. X-ray oscillation diagram of oriented silicon-spinel around [110] of spinel and [010] of parent kaolinite

the (111) close-packed oxygen planes of the spinel lying parallel to the oxygen sheets of kaolinite, and with octahedral units in parallel orientation in the two structures.

The structure of mullite is not known in detail but is believed to be chain-like, resembling kyanite and sillimanite. Such a structure can be developed from the octahedral sheets of the silicon spinel with only minor rearrangements. The composition of mullite may not have a precisely fixed alumina/silica ratio and this also can be fitted into the general pattern of the reaction process.

A feature of these transitions is that, after the initial dehydration of kaolinite, the reaction process can be regarded as a progressive diffusion of silica from the structure. Stages in the reaction sequence, expressed in terms of chemical compositions, should be regarded as ranges of composition and not as specific chemical compounds. The reaction sequence may then be represented as follows:

$$\underset{\text{kaolinite}}{Al_2O_3.2SiO_2.2H_2O} \xrightarrow[500^\circ\text{ C.}]{} \underset{\text{metakaolinite}}{Al_2O_3.2SiO_2} + 2H_2O$$

$$2[Al_2O_3.2SiO_2] \xrightarrow[925^\circ\text{ C.}]{} \underset{\text{silicon-spinel}}{2Al_2O_3.3SiO_2} + SiO_2$$

$$2Al_2O_3.3SiO_2 \xrightarrow[1100^\circ\text{ C.}]{} \underset{\substack{\text{1 : 1 mullite-type} \\ \text{phase}}}{2[Al_2O_3.SiO_2]} + \underset{\text{cristobalite}}{SiO_2}$$

$$3[Al_2O_3.SiO_2] \xrightarrow[\text{above } 1400^\circ\text{ C.}]{} \underset{\text{3 : 2 mullite}}{3Al_2O_3.2SiO_2} + \underset{\text{cristobalite}}{SiO_2}$$

In terms of 32 oxygen atoms per unit cell of the spinel structure, the silicon-spinel can be written $Si_8Al_{10\,2/3}O_{32}$, which can be compared with magnesium-spinel, $Mg_8Al_{16}O_{32}$, the silicon and magnesium atoms occupying tetrahedral positions. The silicon-spinel is a defect structure, and the number of defects depends on the silicon : aluminium ratio. In the limiting case, which is γ-alumina, the composition is $Al_{21\,1/3}O_{32}$, which also is a defect spinel. There seem to be no *a priori* reasons against increasing the number of defects and incorporating most of the silicon in the spinel phase. Careful measurements show that the lattice constant is somewhat less than that of γ-alumina, as would be expected if silicon replaces aluminium in tetrahedral sites. It also explains the absence of more than a trace of cristobalite at this stage. Cristobalite appears clearly when the spinel-phase is transformed to mullite at about 1,100° C., which is an entirely logical result for a silicon-spinel, but finds no explanation in terms of γ-alumina.

The suggestion of a 1 : 1 mullite-type phase is put forward tentatively. The lattice constants of mullite and also the intensities of certain lines in the X-ray powder diagram appear to change progressively as the temperature is raised, and cristobalite becomes more clearly defined. Thus the withdrawal of silica probably continues after the first appearance of mullite. Absence of any marked orientation in the mullite X-ray patterns can be understood in terms of the parent spinel phase, and the results are not necessarily at variance with the apparent orientation of mullite needles shown by electron micrographs of the surfaces of heated kaolinite flakes[4].

A detailed account of this work will be submitted to the *Journal of the American Ceramic Society*. The

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Thaw Rigor and Cell Rupture

In a recent communication, Marsh and Thompson[1] showed that strips of sheep muscle frozen before the onset of rigor mortis could be made to shorten by different amounts by varying the rate of thawing. They further showed that if the muscle shortened by more than 50 per cent of its original length it exuded much fluid, and they concluded that the cell membranes had been ruptured by the excessive contraction, the muscle entering what has been called the delta state.

There is a chemical method for estimating cell damage: deoxyribonucleic acid phosphorus is assayed in the muscle press juice, and its concentration taken to be proportional to sarcolemma rupture[2]. When post-rigor cod fillets are frozen and thawed, the amount of damage has been shown by this technique to be dependent on the velocity of freezing, and well-defined zones of cell damage[3] have been observed at freezing times (times for the centres of the fillets to cool from 0° to −5°) of about 25, 80 and 200–500 min. (peaks *A*, *B* and *C* respectively).

When we froze cod fillets before rigor, we found unexpectedly that there was less cell damage at all rates of freezing (lower curve, Fig. 1) than in the post-rigor controls, and that there was no sign of peak *B* damage, although the rates of freezing employed covered the range in which it normally appeared. It was well marked in the post-rigor controls (upper curve, Fig. 1). Both groups of fillets in Fig. 1 were thawed in 5 hr. at room temperature; a further pre-rigor series, thawed in 10 min. by placing them, wrapped in polyethylene film, in water at 30° gave very similar results to the series shown, with deoxyribonucleic acid phosphorus values ranging from 0·172 to 0·265 mgm. per 100 ml. expressible fluid.

Since we used whole fillets, not thin strips of muscle, it was not possible to thaw out more quickly than this without risking denaturation of the proteins. Consequently, we did not obtain shortenings as great as 50 per cent, which is the minimum required for cell rupture[1]. In the more slowly thawed series (lower curve, Fig. 1) there was no appreciable shortening, while in the series thawed in 10 min. (not illustrated) the shortening ranged from 4·5 to 21·4 per cent. While these results are not, therefore, at variance with those of Marsh and Thompson, they do show that where pre-rigor muscle has not entered the delta state it is less damaged by ice under these conditions than is post-rigor muscle.

Histological sections of all the frozen samples illustrated in Fig. 1 showed that there was a tendency for the ice crystals in pre-rigor muscle to be smaller

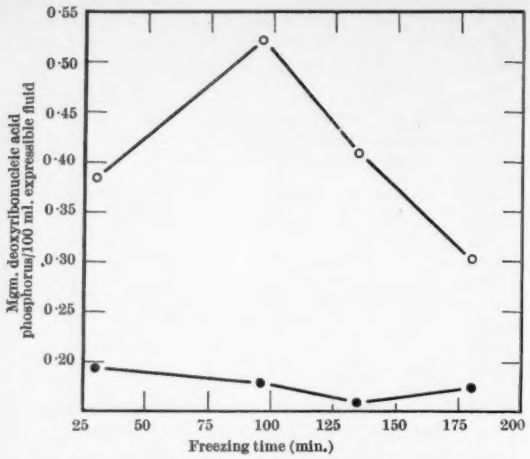

Fig. 1. Concentration of deoxyribonucleic acid phosphorus in the expressible fluid of thawed cod fillets frozen at different speeds. (This concentration is directly related to the cell damage caused by ice formation.) ○—○, Post-rigor when frozen; ●—●, pre-rigor

in size than those in post-rigor muscle identically treated. The reason is not at present known, but it could be connected with the difference in levels of intracellular inorganic phosphate (from adenosine triphosphate) under the two conditions.

It is hoped to publish a full account of this work elsewhere.

The work described in this communication is part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research.

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Use of Deep-Freezing in the Preservation and Preparation of Fresh Soil Samples

In the course of determining the levels of mineral nitrogen in soils, and the extra amounts produced on incubation, a method of maintaining soil samples in their field condition was required. The use of chemical inhibitors to stop microbiological activity was rejected since these change the balance of the soil micro-organisms. A further difficulty was that when arable land is sampled in the winter or early spring the structure of medium and heavy textured soils is destroyed by the operations involved. It was hoped that maintaining soils about freezing point would arrest microbiological activity without altering the results of subsequent incubation and also that freezing would restore or even improve the structure.

Soil samples were taken from the untreated plots of four winter-wheat experiments. A first set of samples was taken during January and a second set during February. The samples taken during January

were sub-divided and stored at 2° for periods up to 28 days. After storage the ammonium and nitrate nitrogen were extracted and estimated from duplicate portions of each sub-sample, by the method of Bremner and Shaw[1]. The mean ammonium and nitrate nitrogen content of the four sub-samples increased from 8 to 15 p.p.m. during 28 days storage, indicating that storage at 2° did not maintain the soils in their field condition.

The second set of samples was divided and the sub-samples were either frozen continuously (−10°), or frozen (−10°) and thawed (2°) alternately for two days at each temperature. The soils were frozen and thawed to see if large samples could be kept in fresh condition by freezing and also be thawed from time to time for the removal of sub-samples. The sub-samples kept continuously frozen for 32 days showed no change in their ammonium and nitrate content; but the mean mineral nitrogen content of the samples alternately frozen and thawed increased from 8 to 20 p.p.m. during the same period. Comparing the increase in mineral nitrogen during 28 days storage at 2° (7 p.p.m.) and 32 days of alternate freezing and thawing (12 p.p.m.), showed that the latter treatment caused more mineralization of soil organic nitrogen than a constant temperature just above freezing point, and was therefore less satisfactory for maintaining soils in their fresh condition when repeated sub-sampling was required.

The ammonium and nitrate levels were estimated in duplicate portions of each sub-sample immediately after storage; further duplicate portions were incubated at 25° for 21 days and then the mineral nitrogen content was determined. The remainder of each sub-sample was air-dried and ground to pass a 2-mm. sieve. The increases of ammonium and nitrate nitrogen on incubation of the air-dry soils were determined after adding water to restore their original moisture contents. These increases in mineral nitrogen on incubation, both for fresh and for air-dry soils, are given in Table 1. Freezing the soils for periods up to 32 days did not affect significantly the amount of mineral nitrogen produced on subsequent incubation of the fresh soils, compared with the increase given by the samples incubated as soon as they were received from the field; this comparison was used to assess the effects of the treatments. Alternately freezing and thawing the soils over a period of 32 days gave a significant increase in mineral nitrogen on subsequent incubation. As is common in this work the amount of mineral nitrogen produced on incubation of the air-dry soils was much greater than the increase obtained when fresh soils were used[2]. The sub-samples frozen for 8 or 32 days, and then alternately frozen and thawed for 8 days, did not behave in a significantly different way when they were air-dried and then incubated. Soils frozen for 16 days or frozen and thawed for 16 or 32 days gave significantly less mineral nitrogen on subsequent incubation. Storage at −10° arrests the equilibrium between organic and inorganic nitrogen in soils for periods up to 32 days, but when the soil is required for use in the air-dry state cold storage should be limited to about 8 days.

Table 1. Effects of Different Conditions of Cold Storage of Fresh Soils on the Extra Mineral Nitrogen produced on Subsequent Incubation. (The Results are the Averages of Four Soils)

All measurements are in parts per million of total inorganic nitrogen

Days of storage	Increase in mineral nitrogen content on incubation after storage at: − 10° continuously	− 10° and 2° alternately
	Fresh soils	
0	20	
8	25	25
16	22	22
32	24	27
	Least significant difference ($P = 0{\cdot}05$) ± 6·3	
	Air-dry soils	
0	58	
8	58	58
16	50	50
32	56	51
	Least significant difference ($P = 0{\cdot}05$) ± 5·1	

A valuable feature of the method was that the physical conditions of the soils were much improved. After freezing, medium and heavy soils had good crumb structures which greatly facilitated sub-sampling and improved aeration during incubation. Soils which had been frozen were more easily crushed and sieved after they had been air-dried. All freshly taken soil samples are now given a short period of deep-freezing to condition them before incubation. In addition deep-freezing is used to store soils for periods up to 8 days when they are required for subsequent incubation after air-drying and for periods up to 30 days when the soils are required only in the fresh state.

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A New Method for separating Strychnine and Brucine by Paper Chromatography

Several papers[1,2] have been published on the separation of strychnine and brucine by paper chromatography, but none of these gives a satisfactory separation of these alkaloids, particularly in regard to the quantitative determination of strychnine after its elution from the chromatogram. The difference between the R_F values of strychnine and brucine is only 0·15–0·18 even under the optimum conditions.

One of us[3] has developed a polarographic and oscillographic method for the determination of brucine based on the finding that small amounts of brucine are quantitatively and instantaneously converted into *o*-brucichinone in 4 *N* nitric acid at room temperature. Strychnine is not affected by this procedure. We have made use of this observation for the separation of strychnine and brucine by means of paper chromatography.

The following method was developed: To 1 ml. of an alcoholic or aqueous solution containing at least 1 mgm. strychnine and brucine, 0·3 ml. of concentrated nitric acid ($d = 1{\cdot}41$) is added, and after 1 min. the solution is neutralized with 2 ml. sodium hydroxide (15 per cent), and the *p*H is adjusted with concentrated acetic acid to 4–5. The solution is made up to a known volume, for example, 3·5 ml., with water. An aliquot of this solution, containing 30–100 μgm. of strychnine, is spotted on strips of Whatman No. 1 filter paper, which have been impregnated with formamide/methanol 1 : 1 v/v in the usual way. The chromatogram is developed by the conventional descending chromatographic technique, using Partridge's solution (butanol/acetic

acid/water, 4 : 1 : 5, v/v/v) as the mobile phase. At a temperature of 22° C. the solvent front travelled about 24 cm. from the starting line in 6 hr.

After drying the chromatogram, the strychnine (R_F 0·76) was detected on control chromatograms by spraying them with the very sensitive Draggendorf's reagent. The *o*-brucichinone (R_F 0·1) remains as a red spot near the starting line.

For quantitative determinations we chromatographed standard solutions of known strychnine concentrations. The content of strychnine was determined after the elution of the part of the chromatogram containing strychnine. It is easy to locate the strychnine from the control chromatograms.

For the quantitative determination any convenient physico-chemical method (for example, photometry) can be used.

We have applied this method to the determination of strychnine in the seeds of *Strychnos nux vomica* L.

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Gamma-Aminobutyrylcholine

As is generally admitted, acetylcholine is not the only cholinergic neurotransmitter, but other choline esters such as propionyl-[1], butyryl-[2], imidazoleacrylyl-[3] and dimethylacrylyl-choline[4] are also contained in the brain and other organs. On the paper chromatogram (solvent : butanol, ethanol, acetic acid and distilled water (8 : 2 : 1 : 3); colouring reagent : Dragendorff's reagent) of the base mixture, isolated as reineckate from trichloracetic acid extract of the dog brain, we noticed a spot around R_F 0·2, which appeared to be different from all the choline esters discovered to date. Among the choline esters synthesized by us, the existence of which in the organism is theoretically possible, gamma-aminobutyrylcholine also had R_F 0·2. (This ester was synthesized with the help of the Research Division, Daiichi Seiyaku Co., Tokyo. Melting point of the hydrochloride : 193° C. Analysis (per cent) : found : C, 41·14; H, 9·12; N, 10·675; Cl, 26·99; calculated : C, 41·38; H, 8·64; N, 10·736; Cl, 27·15.) Besides this the methanol extract of the spot with R_F 0·2 cm. in the brain chromatogram gave a spot with R_F 0·9 when hydrolysed and chromatographed again (solvent : water-saturated phenol; colouring reagent : ninhydrin). This is close to gamma-aminobutyric acid (R_F 0·77).

The pharmacological effects of the various derivatives of choline are as follows. *LD*50, determined with 5 mice per dose group, in mgm./kgm. mouse : gamma-aminobutyryl- 3·5, butyryl- 115·0, propionyl- 550·0, acetyl- 350·0. Gamma-aminobutyrylcholine is by far the most potent, its *LD*50 being about 1/100 of that of acetylcholine.

Muscarinic and nicotinic actions of the choline esters (injected in the femoral vein) were determined by the fall of the carotid blood pressure before, and its rise after, atropinization (2–4 mgm.) in the cat anæsthetized with urethane. The muscarinic effect was most pronounced with acetylcholine; then followed propionyl-, butyryl- and gamma-aminobutyrylcholine, the potency decreasing exponentially in that order. Gamma-aminobutyrylcholine was peculiar in its action. It had no effect in doses smaller than 0·1 ml. of a 10^{-2} *M* solution, and this dose caused a slight but relatively prolonged fall (1 mm. mercury), then a rise, in blood pressure followed by death. For the nicotinic action of the choline esters, the order of efficacy was inverted, and the difference of potency between them was arithmetical. Gamma-aminobutyrylcholine at a dose of 0·5 ml. of a 10^{-2} *M* solution caused a distinct rise in blood pressure (15 mm. mercury), death following immediately.

In assay with the eserinized frog rectus, an exponential gradient of potency similar to that of the muscarinic action on the blood pressure of the cat was noticed. Concentrations of the choline esters and the contractions which they bring about are : 10^{-3} *M* gamma-aminobutyryl- 3 mm., 10^{-4} *M* butyryl- 14 mm., 10^{-5} *M* propionyl- 31 mm. and 10^{-6} *M* acetyl- 12 mm. D-tubocurarine depressed the effect of all the choline esters.

All the esters except gamma-aminobutyrylcholine caused an isolated piece of guinea pig ileum to contract. At concentrations of 5×10^{-6} *M* : butyryl- 14 mm., propinyl- 53 mm., and acetyl- 77 mm.; pretreatment with atropine blocked their action. However, gamma-aminobutyrylcholine had no action even at a concentration of 5×10^{-3} *M*. On the contrary, it elicited a slight anticholinergic action, and at 5×10^{-3} *M* depressed the contractile activity of $5{\cdot}5 \times 10^{-6}$ *M* acetylcholine by 12·9 per cent (average of six experiments).

The antihistaminic action of gamma-aminobutyrylcholine was more pronounced. Contraction of the ileum of the guinea pig by $5{\cdot}4 \times 10^{-6}$ *M* histamine was completely blocked at 5×10^{-3} *M*, and it was depressed 82·6 per cent at 5×10^{-4} *M*. However, when the concentration of histamine was raised to $5{\cdot}4 \times 10^{-5}$ *M*, gamma-aminobutyrylcholine scarcely affected the contraction.

Histamine and acetylcholine are stimulators of gastric secretion, which makes experiments on the effect of choline esters on gastric secretion interesting. The result of experiments performed on the rat by the method of Friedman and Sandweiss[5] is shown in Table 1. Gamma-aminobutyrylcholine inhibited secretion, and even 0·05 ml. of 10^{-4} *M* solution (intraperitoneally) was apparently effective in reducing free hydrochloric acid as well as total acidity. The other choline esters acted like acetylcholine, enhancing acid secretion, though only at fairly high doses.

Table 1. Effect of Choline Esters on the Gastric Secretion of the Rat (Average of Three Experiments)

Esters	Dose	Volume (ml.)	Free hydrochloric acid (m.equiv.)	Total acidity (*N*)	No. of experiments
Control		0·5	28·5	0·059	6
Acetylcholine	10^{-3} *M*, 1·0 ml.	0·57	37·6	0·084	5
Gamma-aminobutyrylcholine	10^{-3} *M*, 0·05 ml.	0·4	0	0·037	3
	10^{-2} *M*, 0·05 ml.	0·58	0	0·041	3
	10^{-4} *M*, 0·05 ml.	0·32	12·0	0·048	3
Butyrylcholine	10^{-1} *M*, 0·05 ml.	0·5	33·3	0·083	3
	10^{-2} *M*, 0·05 ml.	0·47	26·3	0·057	3
Propionylcholine	1 *M*, 0·05 ml.	0·47	24·0	0·093	3
	10^{-1} *M*, 0·05 ml.	0·43	21·7	0·08	3

The observations described show that gamma-aminobutyrylcholine behaves peculiarly and suggest that it may be an inhibitory neurotransmitter. Glycylcholine, an ester like gamma-aminobutyrylcholine, but with the amino-group in the alpha- instead of the gamma-position, had an action similar to, but much weaker than, acetylcholine.

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Chemical Determination of Deoxyribonucleic Acid in Root Tips before and after Cold Treatment

It has been suggested[1,2] that the deoxyribonucleic acid content of *Trillium* chromosomes in the roots falls after cold treatment, and that the competition for available nucleic acid often leads to starvation of the heterochromatic segments. Photometric determinations of the Feulgen stain content of nuclei before and after cold treatment[3,4] support this view. We have now made estimations of the deoxyribonucleic acid content in root tips of *Vicia*, *Trillium* and *Paris*, both with and without cold treatment (Tables 1–3). In each case, terminal 1-cm. segments were used.

Table 1. Deoxyribonucleic Acid Content in *Vicia faba* Roots

	No. of cells per 1 cm. tip	Deoxyribonucleic acid (μgm.) per 1 cm. tip determined as			Deoxyribonucleic acid per cell (gm. × 10^{-11}) determined as		
		phosphorus	sugar	bases	phosphorus	sugar	bases
Control	480,600	28·4	33·21	32·85	5·91	6·91	6·84
3 days at 5° C.	414,400	26·5	30·21	28·57	6·39	7·29	6·89
3 days at 0° C.	485,600	28·8	34·62	31·28	5·93	7·13	6·44

Table 2. Deoxyribonucleic Acid Content in *Trillium erectum* Roots

	No. of cells per 1 cm. tip	Deoxyribonucleic acid (μgm.) per 1 cm. tip determined as		Deoxyribonucleic acid per cell (gm. × 10^{-11}). Average value from both determinations
		sugar	bases	
Control	278,000	13·46	13·53	4·85
4 days at 5° C.	290,000	14·00	15·98	5·17
Control	279,000	15·73	17·41	5·94
4 days at 0° C.	280,000	16·71	18·80	6·34

Table 3. Deoxyribonucleic Acid Content in *Paris polyphylla* Roots

	Fresh weight of roots (gm.)	Deoxyribonucleic acid (μgm.) determined as			Deoxyribonucleic acid (μgm.) per mgm. fresh weight
		phosphorus	sugar	bases	
Control	0·2405	109·8	119·0	117·8	0·480
4 days at 0° C.	0·2681	166·7	182·3	172·7	0·649

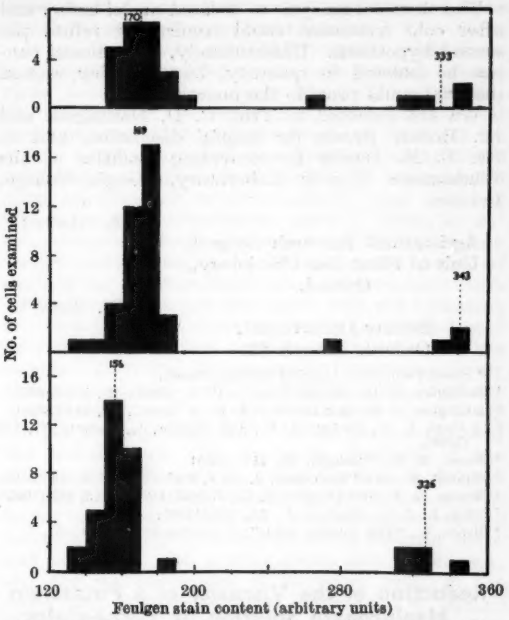

Fig. 1. Feulgen stain content in nuclei of *Trillium cernuum* roots under various conditions. Top, control; middle, 4 days at 0° C., 1 day at 20° C. (in colchicine); bottom, 4 days at 0° C., 1 day at 0° C. (in colchicine)

The number of cells in the terminal cm. of *Vicia* roots suggests that cell division is suppressed at 5° C. and that both division and expansion are suppressed at 0° C. The results for *Trillium* roots indicate that cell expansion is suppressed at 5° C., while at 0° C. both division and expansion are reduced.

Deoxyribonucleic acid was extracted and precipitated by the method of Schmidt and Thanhauser[5] with slight modifications[6]. Dissolved in hot 0·5 *N* perchloric acid it was analysed for phosphorus[7], deoxyribose[8] and base content (by absorption at 260 mμ).

The chemical estimations indicate in every case, whether based on measurements of phosphorus, deoxyribose or base content, a slight increase in deoxyribonucleic acid per cell after cold treatment.

On the other hand, if we take the Feulgen stain content to represent the deoxyribonucleic acid content, the results of La Cour *et al.*[3] and our own (Fig. 1) indicate a fall of up to 25 per cent in the nuclei of *Paris*, *Trillium*, etc.

In the chemical analyses, whole cells are involved, whereas in the photometric measurements, nuclei alone are analysed. Since the chemical analyses depend upon the estimation of precipitated deoxyribonucleic acid, and precipitation depends upon a high degree of polymerization, it is possible that after cold treatment there is a reduction in the proportion of smaller units, say, polynucleotides, which would not be detectable by chemical analysis. The second possibility is that cold treatment causes a loss of Feulgen-positive material from the nucleus into the cytoplasm. Such a process would clearly have to be reversible, since the nuclei can regain their original composition 24 hr. after their return to room temperature.

The chemical analysis of isolated nuclei before and after cold treatment could confirm or refute the second hypothesis. Unfortunately, plant nuclei cannot be isolated in quantity, but probably animal material could provide the answer.

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Reduction of the Viscosity of a Potassium Hyaluronate Solution by Ultra-violet Irradiation

In experiments on the immediate effects of ultra-violet irradiation on connective tissue we have demonstrated a marked reduction of the viscosity of potassium hyaluronate solutions, the reduction being as pronounced as that obtained with hyaluronidase. The effect has been determined *in vitro* by the viscosimetric method described in 1948 by Dalgaard-Mikkelsen and Kvorning[1].

As radiation source we used a Philips (*R**) high-pressure mercury lamp (*HP* 125 *W*) without the glass filtering bulb. The total intensity of radiation was approximately 95 ergs/mm.^{2}/sec. In Fig. 1 are shown values for viscosity and irradiation time.

No significant reduction in viscosity was observed after the interposition of a Chance (*R**) glass filter *OX* 1, but considerable reduction was obtained with an *OX* 7 filter; therefore, the active wave-lengths must be less than 300 mμ.

In the experiments made so far we have observed no effects due to the presence or absence of physically absorbed oxygen. The addition of light-sensitizing substances has, in contrast to the observations of Castellani[2], accelerated the reduction of viscosity only slightly. Ultra-violet irradiation has no effect on the viscosity of a chondroitine sulphate solution under similar conditions.

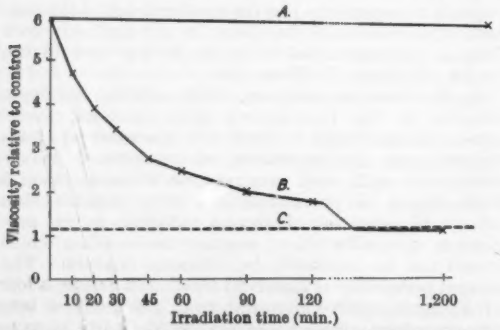

Fig. 1. Variation of viscosity of potassium hyaluronate solutions during ultra-violet irradiation (phosphate buffer, *p*H 6·8). *A*, Control solution stored at room temperature in darkness; *B*, irradiated solutions; *C*, solution treated with excess hyaluronidase

By the method for measuring the spreading of solutions in subcutaneous tissue of mouse skin[3], we found a markedly increased spread of saline (0·9 per cent) in skin irradiated on the inside for 1 min. immediately after the animals were killed. The effect corresponds closely to that obtained by adding hyaluronidase to the saline.

Using the method for demonstrating increased capillary permeability (intracutaneous injection of test solutions into guinea pigs immediately after intravenous injection with pontamine sky blue), we found no difference between the effect of an irradiated and an untreated hyaluronate. Therefore the vascular phenomena in the inflammation caused by ultra-violet light are probably not directly due to substances formed from hyaluronic acid.

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Polymerization–Depolymerization of Tobacco Mosaic Virus Protein

Knight and Lauffer[1] reported that nucleic acid-free protein, obtained by degrading tobacco mosaic virus in alkaline solutions, tended to aggregate to form rapidly sedimenting particles. Schramm[2] showed that nucleic acid-free rod-like particles resembling tobacco mosaic virus but void of activity could be obtained by allowing the protein, isolated after mild alkaline treatment of the virus, to aggregate. The structure of these nucleic acid-free protein rods has been shown by Franklin[3] to be similar to that of the intact virus, except for the absence of nucleic acid. In other words, the protein sub-units are arranged in a giant helix around a hollow core.

It was pointed out by Knight and Lauffer[1] in 1942 that the aggregation of the alkaline degradation product of tobacco mosaic virus was accelerated by a rise in temperature. Harrington and Schachman[4] showed that at 0° C. protein with a sedimentation coefficient of about 4 S was obtained when tobacco mosaic virus was treated at *p*H 9·8; however, when the reaction was carried out at 25°, nucleic acid-free protein particles with a much higher sedimentation coefficient were obtained. Harrington and Schachman showed that some of these larger particles were produced by polymerizing the 4 S component.

We have now discovered that protein prepared by the degradation of tobacco mosaic virus at *p*H 10·3, purified by means of electrophoresis and high-speed centrifugation, and placed in tenth ionic strength phosphate buffer at *p*H 6·5, become polymerized at room temperature and depolymerized in the cold.

Results for optical density shown for *p*H 6·5 in Table 1 and for viscosity shown in Table 2 demon-

Table 1. THE OPTICAL DENSITY AT $\lambda = 320$ mμ FOR SOLUTIONS OF TOBACCO MOSAIC VIRUS PROTEIN AT VARIOUS TEMPERATURES AND AT VARIOUS *p*H VALUES

*p*H 5·0		*p*H 6·5		*p*H 7·7	
Temperature (°C.)	Optical density	Temperature (°C.)	Optical density	Temperature (°C.)	Optical density
23·8°	0·326	23°	0·409	5·0°	0·016
8·0°	0·325	30°	0·430	14·5°	0·016
29·5°	0·326	11°	0·063	20·2°	0·018
		5°	0·059	25·6°	0·019
		10°	0·054	7·0°	0·018
		27°	0·420	25·5°	0·020
				29·0°	0·026
				7·0°	0·027

The same solution was used at each *p*H and the temperature was varied in the order given.

Table 2. EFFECT OF TEMPERATURE ON THE VISCOSITY OF A TOBACCO MOSAIC VIRUS PROTEIN SOLUTION AT *p*H 6·5

Temperature (°C.)	$(\eta/\eta_0) - 1$
2°	0·035 ± 0·0005
25°	0·099 ± 0·0004
2°	0·037 ± 0·0003

The temperature was changed in the order listed. η is the viscosity of the solution and η_0 is the viscosity of the buffer solvent of the solution. The error shown is the standard error of the mean.

strate clearly that large anisometric particles exist at the higher temperatures and smaller, more symmetrical particles at the lower temperatures. The results in Table 1 were obtained on a single preparation of protein in the sequence indicated. Ultracentrifuge experiments carried out at 4·8° showed only a component sedimenting with a coefficient, S^{w}_{20}, of about 4 S. At 12° components sedimenting at about 4 S and about 25 S at relative concentrations of approximately 7 and 3, respectively, were observed. At 30° no slowly sedimenting material was present, but essentially equal concentrations of components with coefficients of about 40 S and of about 220 S were found. Electron micrographs invariably showed no rods when the protein was sprayed on to the grids and dried at 4°, and always showed rods of the same diameter as tobacco mosaic virus but of somewhat more variable length when the grids were sprayed and dried at about 25° (Fig. 1). As is shown in Table 1 the protein exists only in the polymerized state at *p*H 5·0 and only in the depolymerized state at *p*H 7·7 at the temperatures studied.

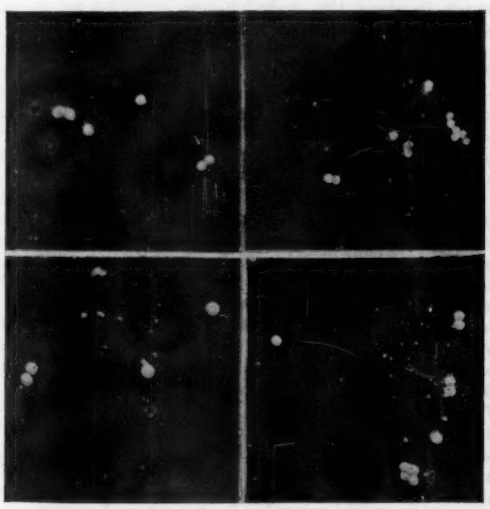

Fig. 1. Electron micrographs of the same tobacco mosaic virus protein solution sprayed on grids at different temperatures in the sequence indicated. *A*, 4°; *B*, 30°; *C*, 4°; *D*, 25°. The reversibility of the polymerization process is demonstrated

It has been well established, therefore, that there is an apparent equilibrium between tobacco mosaic virus protein of low molecular weight and rod-like polymers of various lengths possessing a helical structure, and that polymerization is favoured by higher temperature and depolymerization by lower temperature within the range 0–30°. This dependence upon temperature indicates clearly that the enthalpy for polymerization is positive. Since at 30° polymerization occurs spontaneously, the free energy change must be negative. Therefore, the change in entropy for polymerization must be positive. Such an increase in entropy associated with the formation of a highly ordered structure can be understood only in terms of interaction between the protein and the solvent. Doty and Myers[5] reported that the entropy change associated with the polymerization of the monomeric form of insulin, while negative, was much too low in magnitude to be understood in terms of the translational and rotational freedom of the monomer particles alone. They postulated that the monomer is more hydrated than the dimer and the higher polymers; thus, the polymerization reaction involves both the breaking of bonds between water and monomer, with a consequent gain in entropy, and the immobilization of monomer units in the dimer and higher polymer structure. A similar hypothesis can account for the observation here reported on tobacco mosaic virus. The overall reaction of polymerization then would be: hydrated monomer yields unhydrated polymer plus water, with net increases in enthalpy and in entropy.

Somewhat similar effects of temperature have been reported for the aggregation of sickle-cell anaemia hæmoglobin[6] and of collagen[7] and for the formation of micelles by synthetic detergents[8].

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Activation of Cytochrome Oxidase by Synthetic Detergents

SINCE 1941, sodium cholate or sodium deoxycholate has been used by many investigators to extract and purify cytochrome *a* or cytochrome oxidase[1–10]. However, it is necessary to remove such agents as sodium cholate or sodium deoxycholate from the solution of the enzyme, because they inhibit the cytochrome oxidase activity.

The effects of various types of synthetic detergents upon the cytochrome oxidase activity of a purified preparation of cytochrome *a*, fraction S_4[9,10], were systematically investigated. The cytochrome oxidase activity was measured manometrically under the following conditions: the reaction mixture consisted

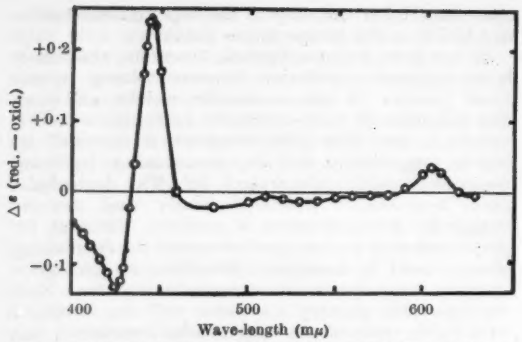

Fig. 1. Difference spectrum of the purified preparation of cytochrome *a*. The preparation of cytochrome *a*, fraction S_4, was diluted with 1 per cent 'Emasol-4130' in 0·1 *M tris*-hydrochloride buffer, *p*H 7·4

of 0·1 ml. of the cytochrome *a* solution, in 2 per cent sodium cholate in 0·1 *M* phosphate buffer, *p*H 7·4, 0·2 ml. of $3{\cdot}23 \times 10^{-4}$ *M* solution of crystalline cytochrome *c*, 0·5 ml. of 0·1 *M* hydroquinone, 0·2 ml. of 10 per cent detergent, and 1·0 ml. of 0·1 *M* phosphate buffer, *p*H 7·4. 0·1 ml. of 20 per cent potassium hydroxide was placed in the centre well. The reaction was started by mixing the hydroquinone with the other components. The uptake of oxygen was measured after 10 min. at 30° C. The iron contents of the fractions were calculated from the difference of optical density between the reduced and the oxidized forms at 605 mμ, and from the extinction coefficient[11]: $0{\cdot}076 \times 10^5$ cm.²/atom iron as $\Delta\varepsilon$ at 605 mμ, mole/l. (red.—oxid.) per cm.

The oxidase activity was expressed as turnover number (moles oxygen/iron atom of hæm/min.). The effect of 'Emasol-4130' was expressed as the relative activity, which was calculated from the following equation:

$$\text{Relative activity} = \frac{\text{oxygen uptake per 10 min. (+ detergent)}}{\text{oxygen uptake per 10 min. (− detergent)}} \times 100$$

It was found that non-ionic detergents increase cytochrome oxidase activity, while the cationic and anionic detergents used in this investigation inhibit it. Under the conditions described, without detergents the cytochrome oxidase activity of the fraction S_4, expressed as the turnover number was 9·4 moles oxygen/iron atom hæm/min. By the addition of 1 per cent 'Emasol-4130', it increased to 32·4, about 10 per cent of the original activity of fraction S_1.

'Emasol-4130', a non-ionic detergent (Kao Soap Co., Tokyo (polyoxyethylene sorbitan mono-oleate, *H.L.B.* 16·5), is the most effective agent of those tested. This agent can solubilize cytochrome *a* easily in place of sodium cholate.

Table 1. Effect of 'Emasol-4130' upon the Cytochrome Oxidase Activity

Fraction	Component	Moles oxygen/iron atom/min.		Effect of 'Emasol' (relative activity)
		−'Emasol'	+'Emasol'	
S_1	*b*, *a*, c_1, *c*	246·0	171·0	70 (inhibition)
S_2	*a*, *b*, c_1	99·4	60·8	61 (inhibition)
$S_{2\cdot1}$		35·5	30·7	86 (inhibition)
$S_{2\cdot2}$	*a* (*b*, c_1)	19·1	24·8	129 (activation)
$S_{2\cdot3}$		9·6	21·0	217 (activation)
$S_{4\cdot1}$	*a*	7·5	22·7	302 (activation)
$S_{4\cdot2}$		9·4	32·4	345 (activation)

The preparation in the 'Emasol' buffer solution shows no significant decrease in activity after storage for two months. 'Emasol-4130' increases the oxidase activity of the purified fractions, $S_{2\cdot2}$, $S_{2\cdot3}$, $S_{4\cdot1}$ and $S_{4\cdot2}$, while it inhibits that of the earlier stage fractions, S_1, S_2 and $S_{2\cdot1}$, as shown in Table 1.

The properties of cytochrome *a* in 'Emasol' solution are now being studied in our laboratory.

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Action of Acetone on the Tonic Muscle of the Frog

Acetylcholine added to Ringer solution in which m. rectus abdominis of the frog (*Rana temporaria*) is immersed causes the well-known acetylcholine contracture of the muscle. The magnitude of this shortening depends on the functional state of the muscle, the concentration of acetylcholine, the temperature of the bath, and on the constituents of the medium surrounding the muscle. Many agents which increase the acetylcholine activity or, when present alone, induce a shortening of the m. rectus, have been described. Some of these, according to their mode of action, can be used for sensitizing biological acetylcholine titration. In some cases this effect can be explained by the inhibition of cholinesterases present in the muscle. According to Torda[1] and Hsi Chung Chang *et al.*[2] acetone is also included in this group.

We have studied the effect of various concentrations of acetone on the acetylcholine contracture of the muscle. The experiments were carried out on the isolated m. rectus hanging in frog-Ringer solution, which was aerated constantly. Acetone, added to the solution shortly before acetylcholine to give concentrations of 0–2 per cent, produced an apparent increase in the acetylcholine contracture. Acetone produced the same effect in tissue extracts used for the estimation of acetylcholine in frozen brain. For the same amount of acetylcholine, there is a linear relationship between concentration of acetone and muscle shortening (Fig. 1). Acetone alone, however, in the range of concentrations mentioned above does not modify the muscle tonus or the functional state of the muscle. Acetone did not increase acetylcholine contracture in the dorsal muscle of the leech. At higher concentrations (more

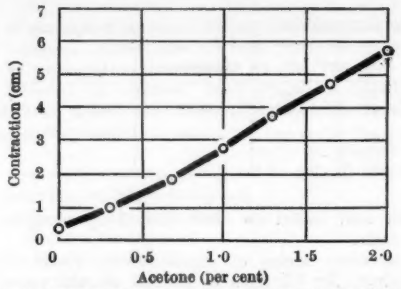

Fig. 1. Contraction produced by varying amounts of acetone with 8×10^{-3} mgm./l. acetylcholine

than 2 per cent) an increase of the muscle tonus and a contracture-like shortening of the muscle was observed with acetone alone. This effect could be abolished by atropine sulphate (10^{-3} mgm./l.).

Further tests have shown that acetone increases the acetylcholine contracture even when physostigmine salicylate is applied as an inhibitor of cholinesterase. The contractures evoked by the same dose of acetylcholine and registered during 10 min. are shown in Fig. 2. From these results it can be assumed that the action of acetone is more complicated than the simple inhibition of cholinesterase.

Studies of biochemical and electrophysiological processes during the activity of the muscle, comparing the contracture with the contraction have shown apparent qualitative differences. This was also observed in our experiments, when the influence of acetone on the tetanic contractions evoked by direct electrical stimulation was investigated. Contrary to the results mentioned above, acetone (0–2 per cent) induced a definite diminution of the contractions. These observations suggest that acetone acts differently on the tonic and tetanic fibres, which have unequal sensitivity to acetylcholine. We must remember that the response of the muscle to acetylcholine applied externally is due to the tonic fibres, while direct stimulation first activates the tetanic ones. Further experiments must be performed to solve this problem.

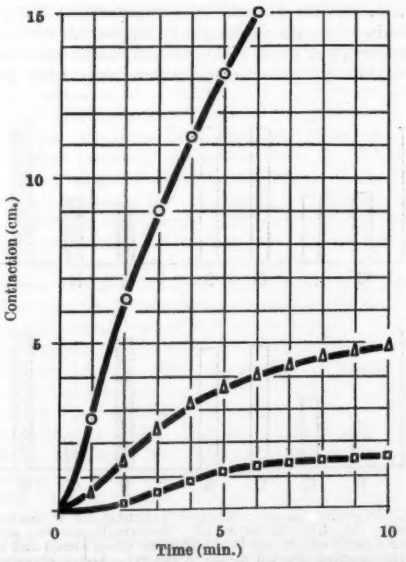

Fig. 2. Effect of acetone (1·3 per cent) and physostigmine + salicylate (2×10^{-5} mgm./l.) on the contraction produced by acetylcholine (3×10^{-7} mgm./l.). ○, Acetone + physostigmine + acetylcholine; △, physostigmine + acetylcholine; □, acetylcholine

According to these results, however, acetone can be used at convenient concentrations as a powerful agent for sensitizing the biological titration of acetylcholine with the m. rectus of the frog, especially when very small amounts (10^{-2}–10^{-9} mgm./l.) are being determined.

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Relationship between Chlorpromazine and Anoxia

THE effects of chlorpromazine on metabolism have been studied thoroughly. The results of Laborit[1], Benite[2] and others show that it has a depressing influence. It was also suggested that chlorpromazine would influence anoxia produced by low oxygen pressure. This question was answered by Cheymol and Levasort[3], and by Rejsic[4] and Ankermann[5]. The results describe a lowered resistance to anoxia produced by chlorpromazine. Bean[6] produced a lowered resistance in Sprague–Dawley rats by administering chlorpromazine while they were exposed to an oxygen pressure of several atmospheres. We know that after a short exposure to oxygen at low pressures an induced polycythæmia occurs in some experimental animals, for example, rats and rabbits. This polycythæmia represents one of the adaptation reactions to anoxia. We have investigated the influence of chlorpromazine on this induced polycythæmia.

The experimental animals chosen were adult Wistar rats weighing about 200 gm. All animals were fed a standard diet and were weighed before the experiment. Exposure was effected by placing the animals in a chamber at a pressure 20 cm. of mercury below atmospheric for 30 min. Before and after exposure blood samples were taken from the tail vein and the red cells counted by the usual method. 10 mgm./kgm. body-weight of chlorpromazine was administered intraperitoneally 1 hr. before the experiment.

In the first series of experiments we determined the red cell count in 82 Wistar rats. The average was 6,090,000 in 1 mm.^{3}, standard error, 63,000. 18 rats were placed in the low-pressure chamber and after exposure the red cells were counted again. The average was 6,800,000 in 1 mm.^{3}, standard error 62,000. This difference is statistically significant (Table 1).

Chlorpromazine (10 mgm./kgm. body-weight) was injected into 16 Wistar rats 1 hr. before counting the red cells. The average count was then 6,000,000, standard error 90,000. After exposure as above, no difference was found. The red cell count was 6,060,000, standard error 120,000. The difference was not statistically significant.

Besides the red cell count we studied the forms of red cells: in the blood of animals without chlorpromazine anisocytosis and poikilocytosis occurred,

Table 1

	No. of animals	Millions of red cells/mm.³	Standard error		χ^2	Difference	t	P
Controls	82	6·09	0·063	± 0·56	26·6			
After anoxia	18	6·8	0·062	± 0·27	1·34	0·71	5·2	<0·001
After anoxia treated with chlorpromazine	14	6·06	0·12	± 0·46	2·76	−0·03	0·3	>0·9

but it was not observed in animals to which chlorpromazine had been administered.

In further experiments we investigated the effect of splenectomy and bilateral epinephrectomy on the induced polycythæmia. After this no significant change in the red cell count occurred during exposure as above.

From our experiments we suggest that the polycythæmia induced by short exposure to anoxia is a reflex effect taking place through the adrenal glands, the effector being spleen. When chlorpromazine in doses of 10 mgm./kgm. body-weight is applied, the development of this reflex is blocked and no adaptation reactions occur.

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Adrenal Cortical Hormones and the Formation of Histamine and 5-Hydroxytryptamine

It has been suggested[1,2] that the administration of adrenal cortical hormones lowers the tissue reserves of histamine by decreasing the rate of its formation. One of the physiological actions of these hormones therefore may be to exert a functional control over the histamine-levels in the tissues. The relationship of adrenal cortical hormones to the production of another tissue amine, namely, 5-hydroxytryptamine, has not been studied, and it was therefore of interest to trace the effects of cortisone and certain of its analogues on the tissue-levels of both amines in the rat and to correlate these changes with alterations in the tissue mast cell population.

Daily doses of cortisone or hydrocortisone (50 mgm./kgm.) were given for 14 days to groups of rats, which were then killed. Several tissues were extracted and tested for histamine and 5-hydroxytryptamine activity, tissues from solvent-injected animals serving as controls. The histamine-levels in the skin areas of the treated groups fell to about 50 per cent of those in the control group, and a similar loss of 5-hydroxytryptamine also occurred (Fig. 1). Degranulation of the skin mast cells was particularly noticeable, but disruption of the cell membrane was absent. In the jejunum and spleen, only histamine depletion was detected. In sharp contrast, similar doses of deoxycorticosterone acetate failed to produce a decrease in the tissue-levels of either amine in any of the tissues studied and failed to alter the morphology of the mast cells.

In another series of experiments, these steroids were given for 14 days to groups of rats previously depleted of histamine by treatment with polymyxin *B*[3]. Such treatment also cleared the tissues of typically staining mast cells, but did not markedly lower the tissue 5-hydroxytryptamine-levels (Fig. 1). When cortisone was given to these rats, the recovery rate of tissue histamine was greatly retarded, but much more striking was the effect on the tissue 5-hydroxytryptamine. The concentration of the latter amine in the skin areas fell dramatically to about 20 per cent of the control values, although depletion in other tissues was much less. The magnitude, but not the rate, of the depletion in the skin resembles that found after treatment with reserpine, a drug which prevents the binding by the tissues of fresh 5-hydroxytryptamine. Again, in sharp contrast, deoxycorticosterone acetate failed to alter the recovery-rate of histamine after its depletion by polymyxin *B*, and did not affect the tissue 5-hydroxytryptamine content. The recovery-rate of mast cells was not affected by either treatment, though in the animals treated with cortisone the new cells always appeared to be less granular than in the rats treated with deoxycorticosterone acetate.

It is suggested that cortisone and other glucocorticoids lower the activity of both histidine decarboxylase[2] and 5-hydroxytryptophan decarboxylase, whereas deoxycorticosterone acetate and other mineralocorticoids are devoid of this action. The reduction in the decarboxylase activities by glucocorticoids becomes particularly apparent when histamine stores and mast cell concentrations are lowered. Part of the glucocorticoid action may also be the

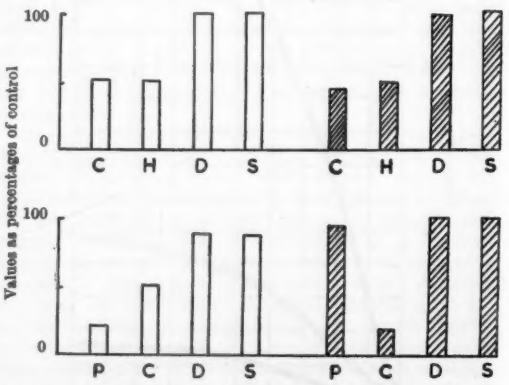

Fig. 1. Upper histograms: effect of treatment for 14 days with cortisone (*C*), hydrocortisone (*H*), deoxycorticosterone acetate (*D*), or solvent (*S*) on the skin histamine (clear areas) and 5-hydroxytryptamine (shaded areas) of the rat. Lower histograms: effect of treatment with polymyxin *B* (*P*), followed by treatment for 14 days with cortisone (*C*), deoxycorticosterone acetate (*D*) or solvent (*S*). All values expressed as percentages of the control levels

result of an upset in the binding mechanisms of the tissue amines. Thus, the adrenal cortical secretion, which is mainly corticosterone in the rat and thus glucocorticoid in nature, may exert a functional control over the tissue-levels of both histamine and 5-hydroxytryptamine.

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Adaptation to Serum-free Medium by a Phagocytic Cell Strain derived from a Murine Lymphoma

The adaptation of mammalian cells to serum-free media in tissue culture has been a subject of considerable interest in recent years. Cells grown in such media would be free from the effects of serum antibodies and other serum inhibitors of micro-organisms, and, therefore, should be suitable for long-term studies of intracellular bacteria as well as rickettsia and viruses. Such cells might also be useful in nutritional studies in tissue culture and in evaluating the effects of heterologous sera on cells in culture.

We have recently been studying *Mycobacterium lepraemurium* in tissue cultures of a continuous line of neoplastic highly phagocytic cells, derived by Dawe and Potter[1] from a lymphocytic neoplasm (strain *P*388) of *DBA*/2 mice. This cell line was originally isolated in a medium containing 40 per cent human serum and seemed to require serum for growth.

In order to avoid contact of the murine leprosy bacilli with serum, the cells were transferred to a serum-free maintenance medium prior to infection and remained in this medium throughout the experiments. Since the cells rapidly deteriorated in the complete absence of protein, a maintenance medium consisting of 20 per cent autoclaved fatless milk and 80 per cent medium No. 199 was selected. This medium has recently been described by Baron and Low[2] in virological studies and seems to be extraordinarily suitable for prolonged maintenance of human and monkey cells. We have prepared our medium essentially according to the methods described by Baron and Low.

'Instant Pet Nonfat Dry Milk' (manufactured by Pet Milk Co., St. Louis, Mo.), is reconstituted according to the directions of the manufacturer in triply distilled water. The milk is autoclaved at 7·5 lb. pressure for 15 min. The *p*H of the autoclaved milk is then brought to approximately 7·2 by the addition of 5 c.c. of 5 per cent sodium bicarbonate per 100 c.c. of reconstituted milk. The autoclaved milk is then added to medium No. 199 to prepare a mixture containing 20 per cent fatless milk and 80 per cent No. 199. Prior to use, the *p*H of the 20 per cent fatless milk medium is adjusted to approximately 7·4 with 5 per cent sodium bicarbonate. Medium No. 199 is prepared from a stock concentrate obtained from Microbiological Associates, Bethesda, Md. We add 50 units of penicillin to each ml. of medium No. 199.

Seven tube-cultures of *P*388 cells grown without plasma-clot in a medium of 40 per cent human serum and 60 per cent No. 199 were washed twice in serum-free No. 199 fluid and placed in the medium consisting of 20 per cent fatless milk and 80 per cent No. 199. They were then infected with *Mycobacterium lepraemurium*. Examination of one of these cultures after Ziehl–Nielsen staining showed large numbers of intracellular acid-fast bacilli. During the first week after infection, the *p*H of the media in the tubes was lowered rapidly and daily feeding was necessary. During the second week, many of the cells developed nuclear pyknosis and began to detach themselves from the glass surface. After three weeks, very few cells still adhered to the dependent surfaces of the tubes, and *p*H changes in the media were extremely slow. Seven weeks after transfer to the milk medium, small clusters of proliferating *P*388 cells were seen in several of the tubes. These slowly increased in number and by fourteen weeks the tubes had become repopulated with cells morphologically indistinguishable from the original *P*388 cultures. Acid-fast bacilli were not seen in these cells. At this time, daily feeding of cultures became necessary.

Cells from a single tube were scraped from the glass surface with a pipette, resuspended in fresh fatless milk medium, and transferred to a 2-oz. prescription bottle. They rapidly became adherent to the glass surface of the bottle and proliferated. After one week, they covered the dependent surface of the bottle. Transfer of cells from other tubes to bottles was easily accomplished in a similar fashion and repeated subcultures have been possible. Cells grown in bottles have been transferred to cover-slips in Leighton tubes for cytological studies with no difficulty. It has been shown that the milk-adapted cell line is still actively phagocytic and studies with *M. lepraemurium* in these cells are in progress.

It has thus been possible to adapt phagocytic tissue-culture cells from a murine malignant lymphoma to growth in a serum-free medium containing 20 per cent autoclaved fatless milk. The use of such cells, free of serum antibodies and inhibitors, in studies of intracellular bacteria as well as rickettsia and viruses is suggested.

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The Dendritic Cell System and Mast Cells in Non-Epidermal Stratified Squamous Epithelium

The occurrence of the dendritic cell system has been investigated in mammalian non-epidermal stratified squamous epithelium. Epithelium was split from the underlying connective tissue by treatment at 4° C. overnight[1] with pancreatin in Hanks balanced salt solution[2] adjusted to *p*H 7·8 with sodium bicarbonate. The epithelium was stained supravitally in a solution of 0·01 per cent toluidin blue and 0·05 per cent sodium bicarbonate in Hanks balanced salt solution for one hour or longer[3] at

room temperature. It was then inspected from the basal side. In this manner the œsophageal epithelium of the cow, the pig, the cat and *Macaca irus* F. Cuv., as well as the epithelium of the vagina and the portio vaginalis uteri of man and *Macaca irus* have been examined. Furthermore, sections of biopsies of the human portio vaginalis uteri, impregnated with gold by the Gairns method as modified by Becker *et al.*[3], have been examined.

In all these epithelia high-level dendritic cells[4] with long slender processes have been found. In the same epithelia basal counterparts of these cells have been found between, or slightly apically of, the Malpighian cells of the stratum cylindricum. They may show no, or only short and blunt, processes. Processes may become progressively more evident in higher strata. Both the high-level dendritic cells and their basal counterparts may stain orthochromatically *intra vitam*, but often fail to do so. In general they contain granules, which exhibit metachromatic staining. In the majority of cases these granules are unevenly distributed in the cytoplasm, often in an excentric agglomeration. Their size may vary within the same cell. The granules can be seen lying in pairs according to size.

Weissenfels[5] has photographed such pairs in chicken embryo melanoblasts, but he does not mention them. Pease[6] has shown double granules in an epidermal 'clear cell' with the electron microscope.

In the epithelia mentioned, cells of the dendritic system may occur together with intra-epithelial mast cells. In the œsophagus of the cat intra-epithelial mast cells can be very common[7]. They can be almost as frequent in the œsophageal epithelium of the macaque. They are not frequent in the œsophageal epithelium of the pig. I have not found any in the œsophageal epithelium of the cow. In human and macaque's vaginal epithelium the frequency of intra-epithelial mast cells is very variable, but may be high in the portio vaginalis uteri.

Intra-epithelial mast cells may resemble dendritic cells because they often have processes which are insinuated between the Malpighian cells. However, their metachromatic granules are uniformly distributed in the cytoplasm and uniform in size. The nucleus and the cytoplasm of mast cells do not stain orthochromatically *intra vitam*.

In distribution as well as in cellular outline, the basal counterparts of the high-level dendritic cells in split epithelium closely parallel the 'clear cells of Masson' in sections of fixed material. The granules are, however, usually not visible in such sections.

The dihydroxyphenylalanine reaction has been tried on split œsophageal epithelium of the macaque, both unfixed and after short fixation in 4 per cent formalin (in Hanks balanced salt solution) or ice-cold 70 per cent ethanol. The reaction has also been tried on biopsies of the human portio vaginalis uteri, according to Becker *et al.*[8], and with presoaking as for the tyrosinase reaction, according to Fitzpatrick[9]. No regularly distributed dihydroxyphenylalanine-positive cells were found in the epithelium. All the positive cells which were found could be interpreted as granulocytes. Activation by copper, according to Yoshida and Togashi[10], was useless.

Dendritic cells cannot be demonstrated by the gold method in young regeneration epithelium of the human portio vaginalis uteri. They may reappear in older regeneration epithelium. Dendritic cells may be found in dysplastic epithelium of the same location and even in atypical epithelium (carcinoma *in situ*).

A full account of this investigation in a wider context will be presented elsewhere.

Living material of *Macaca irus* was kindly put at my disposition by the Netherlands Institute of Preventive Medicine at Leyden.

Note added in proof. In sections of one human portio biopsy with normal epithelium, dihydroxyphenylalanine-positive cells with processes were found to be 'hanging under the epithelium', not unlike active melanocytes in the skin.

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A Simple Method for absorbing Heterologous Antibodies from Precipitating Sera

It is known that in the sera of animals immunized with soluble antigens heterologous antibodies also appear, especially if more than one immunizing dose is applied. Proom[1] found that after three immunizing doses heterologous antibodies appeared in 55–58 per cent of the rabbits immunized. While it is easy to carry out the Castellani absorption with corpuscular antigens and to prepare monovalent antisera, it is very difficult to get monovalent antisera against soluble antigens. Several methods are recommended for removing undesirable antibodies from precipitating sera: absorption at optimal proportion, controlled by quantitative precipitation[2]; several methods attempt to adsorb the homologous antibody on an antigen previously made insoluble, followed by centrifugation to remove the homologous antibody which was later clearly dissociated; thus Haurowitz *et al.*[3] coupled the antigens to dyes, Campbell *et al.*[4] to powdered 'Cellulose' (Solka floc.), Isliker[5] to ion-exchange resins.

I believe I have found a simpler method for obtaining monovalent antisera. I make the heterologous antigens insoluble by adsorbing them on aluminium hydroxide gel and use them to absorb the heterologous antibodies. I used this method for purifying rabbit sera precipitating many kinds of animal serum proteins. 5 ml. of the aluminium hydroxide gel, which contained about 36 mgm. aluminium/ml., was mixed with 10 ml. of the heterologous antigen solution and 15 ml. of physiological saline and shaken thoroughly. 1 ml. of the gel suspension so obtained contained 0·33 ml. antigen and 6 mgm. aluminium. The suspension was centrifuged and the supernatant examined with sulphosalicylic acid. If the test was negative, the adsorption of the antigen protein was complete. The immune serum was purified in the following way: the adsorbed heterologous antigen was centri-

fuged and the supernatant discarded; the packed mass was suspended in the undiluted immune serum and left to stand for 1 hr. at 37° C., and for 2 hr. at 4° C.; after this the gel–antigen complex was centrifuged off, removing the heterologous antibody.

The centrifuged sediment of about 5 ml. antigen–gel suspension was sufficient to absorb one heterologous antibody from 50 ml. undiluted rabbit serum. If the immune serum contains more than one heterologous antibody, they can be absorbed in one operation by previously mixing the necessary antigen suspensions.

The titre of the homologous antibody remained unchanged after purification. We obtained specific monovalent precipitating sera by this method from all of 51 rabbits which were immunized against human, horse, cow, pig and dog serum proteins.

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Bacterial Dissimilation of Indoleacetic Acid: a New Route of Breakdown of the Indole Nucleus

AN organism capable of breaking down indoleacetic acid has been isolated in pure culture and characterized as a member of the genus *Pseudomonas* (Migula), but it does not correspond to any of the species described in the sixth edition of "Bergey's Manual of a Determinative Bacteriology".

Percolation of 10 gm. of soil resulted in logarithmic decomposition of 10^{-3} *M* indoleacetic acid after an initial lag of approximately seven days; further additions of 10^{-3} *M* indoleacetic acid were decomposed without a lag at a maximal rate of 0·24 mgm./hr./gm. of soil.

With standard manometric techniques the adaptation to indoleacetic acid was shown to involve simultaneous adaptation to skatole (3-methyl-indole), indoxyl (3-hydroxy-indole), salicylic acid and catechol. No adaptation had occurred to indole, anthranilic acid, *o*-amino-phenol, *o*-nitrophenol, *o*-nitrobenzoic acid or phthalic acid. The initial step in the dissimilation appears to be a decarboxylation, evolution of carbon dioxide slightly preceding the uptake of oxygen.

For aerated cultures, in nitrogen-free medium supplemented with 10^{-2} *M* indoleacetic acid, skatole, indoxyl compounds, salicylic acid and catechol were identified by chromatography on paper. Catechol was isolated as a crystalline compound (melting point, 103° C.) from an ethereal extract of the acidified culture fluid. The sequence of appearance of intermediates was consistent with a route via (*a*) an initial decarboxylation of indoleacetic acid to yield 3-methyl-indole, (*b*) replacement of the methyl group by an hydroxyl group, (*c*) hydroxylation and reduction to give a 2,3-dihydroxy-dihydro-indole, (*d*) splitting of the ring followed by (*e*) hydrolysis to liberate ammonia and the formation of salicylic acid, which is then metabolized through catechol. The ammonia was converted to nitrite and nitrate.

This scheme shows features common to previously postulated routes for aromatic breakdown[1,2], but differs from those for tryptophan[3] and indole[4], in that ring fission does not involve kynurenine or anthranilic acid formation.

I wish to thank Prof. F. S. Stewart for supervising this work, a full account of which will be published elsewhere.

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Carbohydrate Peptide Complex from Egg Albumin

ONE of us described in 1938 the preparation from crystalline egg albumin of a polysaccharide containing mannose and glucosamine and a small amount of an unidentified nitrogenous substance[1]. On the basis of hexose and amino-sugar estimations on the intact protein and the molecular weight of 40,000 then accepted for hen's egg albumin, it was concluded that one albumin molecule contains four mannose and two glucosamine residues. Since the method of isolation involved acetylation, no information could then be obtained as to whether the glucosamine residues were originally present in the N-acetylated form. Since there were no suitable chromatographic methods available in 1938, the work was discontinued and many problems concerning this carbohydrate were left unanswered, particularly the nature of the linkage of the polysaccharide with the peptide chain.

The problem has been taken up again in the last few years in this laboratory and some observations have been made which are here recorded. In the first place, the molecular weight of egg albumin now accepted[2] is approximately 45,000 and the analytical figures with respect to the carbohydrate composition have to be revised. Mannose estimation suggests that the hexose content is about 2 per cent, but the errors of the various methods used may be quite considerable. Similarly, the most reliable value for amino-sugar is 1·2 per cent (in terms of the hexosamine base). These figures indicate that egg albumin probably contains five mannose and three glucosamine units. We have also determined the volatile acids arising on hydrolysis of the protein with 2 *N* hydrochloric acid for various periods of time, and it could be shown by partition chromatography[3] that approximately four molecules of acetic acid were produced. The conclusion that this acid arises largely from N-acetyl-glucosamine residues was supported by the finding that hydrolysis of the complex peptide to be described below yields the acetylamino-sugar, which was identified by paper chromatography.

A peptide–carbohydrate complex was obtained by the following procedure. The heat-denatured protein was hydrolysed, first with pepsin at *p*H 2·8, then by a mixture of trypsin and chymotrypsin at *p*H 7·8 and finally by a mould protease described by Crewther and Lennox[4]. The hydrolysate was chromatographed on a carbon–'Celite' column and the carbohydrate-containing material was obtained by gradient elution with ethanol–water. Final purification was carried

out by column electrophoresis[5], first at *p*H 7·0 and then at *p*H 2·0. The material thus obtained appeared to be homogeneous on paper electrophoresis between *p*H 2·0 and *p*H 8·0 and could not be further fractionated on a charcoal column. It did not move from the origin on paper chromatography using a number of solvent mixtures, but the material appeared to be positively charged below *p*H 3·0. The complex contained five mannose residues, three glucosamine residues, approximately one residue of leucine and aspartic acid and about 0·5 mole of serine and threonine. The amino-acids were determined by a semi-quantitative method using paper chromatography. Nitrogen estimation indicated that there were seven nitrogen atoms per 5 molecules of mannose; on hydrolysis with *N* sulphuric acid at 100° C. ammonia equivalent to somewhat less than 1 mole was liberated. The serine and threonine results suggest that the material is still not homogeneous.

On allowing the complex to react with 1-fluoro-2 : 4-dinitrobenzene under the conditions used by Sanger[6] there was no reaction within 2 hr. However, prolonged reaction at 37° and *p*H 8·0 gave quantitative dinitrophenylation; it was not possible to separate carbohydrate from the dinitrophenyl-peptide. On hydrolysis, dinitrophenyl–aspartic acid was obtained. On treatment with carboxypeptidase, leucine, serine and threonine only were liberated; on fractionation of a two-day digestion product, a carbohydrate-containing fragment was obtained, which contained 1 mole of aspartic acid, only traces of serine and threonine, and no leucine.

On the evidence at present available, it appears that the aspartic acid residue is directly linked with the carbohydrate through one of the carboxyl groups and with leucine through the other carboxyl group. We are still ignorant as to the source of ammonia and we cannot exclude the possibility that aspartic acid is linked to the carbohydrate moiety through a substance the presence of which has not been revealed by the methods used so far. A complex from egg albumin containing mannose, glucosamine, leucine and aspartic acid has also been obtained by Jevons (following communication), whose results are similar to those obtained by ourselves. In addition, a glycopeptide of similar composition, but also containing tyrosine and valine, has recently been obtained after enzymic hydrolysis of egg albumin by Cunningham, Nuenke and Nuenke[7]. Another series of glycopeptides has recently been isolated from human γ-globulin[8], and it is of interest that in this case evidence was obtained that the carbohydrate is linked with the peptide through aspartic acid.

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Linkage of Carbohydrate to Protein in Ovalbumin

In mucoproteins and mucopolysaccharides, carbohydrate and amino-acid moieties are firmly linked by covalent bonds, the nature of which remains a subject for speculation. The participation of hexosamine is suggested by the fact that it seems invariably to be present in proteins containing firmly bound hexose[1]. O-glycosidic links involving the hydroxyl groups of threonine (or serine) have been proposed[2]; the preponderance of threonine over other amino-acids is marked in purified blood-group substances[3]. Combination between reducing groups of sugars and amino-groups of amino-acid residues is another possibility[4,5]; a glycosylamine link formed in this way could be stabilized by an Amadori rearrangement from an aldose to a ketose derivative.

Ovalbumin was chosen for the present study because of its relatively simple carbohydrate composition. Neuberger[6] showed that it contains a single carbohydrate group composed of mannose and glucosamine only. By digestion with pancreatic proteases and a procedure involving acetylation and deacetylation, he obtained a material containing these sugars together with unidentified nitrogenous constituents. A similar product has now been prepared by treating ovalbumin (3–5 times crystallized[7], either native or heat-denatured) with a crude pancreatic extract (British Drug Houses trypsin, preparation 249949/430612). The enzyme preparation was added in portions over a period of two weeks, during which the *p*H was maintained in the range 7·5–8 by additions of dilute ammonia solution, and the incubation was carried out at 37° C. under toluene. After deproteinization with trichloroacetic acid (5 per cent), and removal of the reagent by repeated extraction with ether, the solution was passed through a column of the sulphonated ion-exchange resin 'Dowex 50' in the H^+ form to remove most of the amino-acids and peptides. The unadsorbed material was submitted to paper electrophoresis[8] in 0·05 *N* ammonium acetate.

Testing eluates with the orcinol reaction[9] showed that the mannose-containing material remained near the origin, while other ninhydrin-positive components moved towards the anode. The carbohydrate-containing material was eluted with water, precipitated with ethanol (5 volumes) and ether (5 volumes), redissolved in water and freeze-dried. The mannose content[9] of such preparations was 40–42 per cent, and accounted for 50–55 per cent of the mannose of the original ovalbumin. The reducing power[10] before hydrolysis was only 0·3 per cent that of mannose on a weight basis. Paper chromatography of acid hydrolysates revealed the presence of aspartic acid, leucine and glucosamine in approximate molar proportions to the mannose of 1 : 1 : 2 : 4, as determined by spot dilution. Other amino-acids were present only in traces, corresponding to molar proportions of 0·2 or less. The unhydrolysed material gave a weak ninhydrin reaction on paper, and reaction with fluorodinitrobenzene in the presence of trimethylamine[11] showed that the amino-group of the aspartic acid residue is free. These results offer no support for the existence of O-glycosidic links. They would be consistent with combination of an amino-acid carboxyl group with glucosamine, but direct evidence for such a bond is lacking.

Since a similar investigation on the carbohydrate of ovalbumin has been carried out by Prof. Neuberger

and Miss Johansen, it has been decided to submit the results for publication simultaneously. A recent note by Cunningham *et al.*[12] reports the identification, after hydrolysis of ovalbumin with purified proteases, of a fragment to which the tentative structure Tyr.Asp-(carbohydrate).(Thr,Ser,Val).Leu was assigned.

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Occurrence of 'Masked Lipid' in Mouse Pancreas

Bensley and Hoerr[1] showed in 1934 that a certain proportion of the cytoplasm of animal cells was insoluble in salt solutions. More recently, Smith and his collaborators[2] have shown that as much as 45 per cent of the material which remains after liver cells have been repeatedly extracted with molar salt solutions is lipid; they suggest that this is a complex lipo-protein. Histochemical studies, using sudan colouring agents and the acid hæmatein test for phospholipids, do not seem to indicate the presence of such large amounts of reactive lipids in many cells. These tests do not, however, exclude the possibility that the lipid is present in a 'masked' condition, a fact which was recognized by Ciaccio[3], who published techniques for detecting lipids when they are combined with other substances.

In the basal region of the pancreas exocrine cell, standard lipid tests (for example, sudan black, Baker[4,5]; acid hæmatein, Baker[6]) do not give a positive reaction (Fig. 1). With the acid hæmatein test, however, a positive reaction is given by the mitochondria and by the zymogen granules in the apical region of the cells. On the other hand, it was found that if the tissue was fixed in Flemming's fluid instead of the formaldehyde–calcium usually employed in the standard acid hæmatein test, and then subjected to the subsequent post-chroming and staining technique exactly as described by Baker[6], the appearance of the cells was very different: the basal region now shows an intense positive reaction (Fig. 2). As this part of the cell can be coloured with sudan black after this fixation, and as all the lipid coloration is abolished if the material is afterwards extracted with pyridine at 60° C. for 24 hr., it is concluded that the fixation with Flemming's fluid is revealing lipids. This unmasking reaction is probably caused by the chromic acid in the fixative. It must be remembered, however, that after fixation in Flemming's fluid, the acid hæmatein technique is no longer a rigorous histochemical test; but, as the reacting material colours with sudan black and therefore must be considered to be a lipid, it is probable that the positive reaction to the acid hæmatein test is due to a phospholipid.

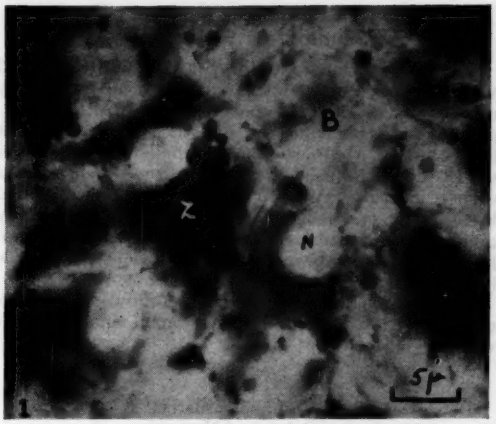

Fig. 1. A section of mouse pancreas prepared by the standard acid hæmatein technique. Note that there is no positive reaction in the basal region of the cells.

Key to Figs. 1 and 2: *B*, basal region of cell; *N*, nucleus *Z*, zymogen granules

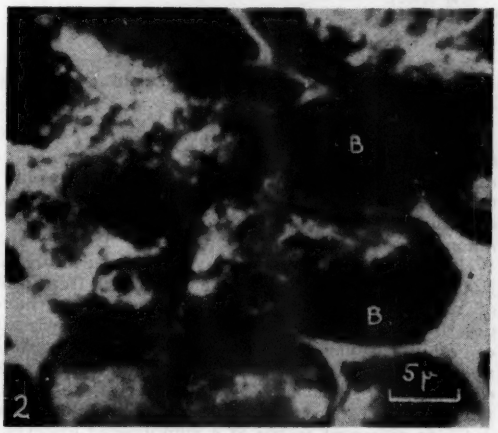

Fig. 2. A section of mouse pancreas prepared by the acid hæmatein technique following fixation in Flemming's fluid. The basal region of the cells is now positive

These observations suggest that there may be large amounts of 'masked' phospholipid, probably in the form of a phospho-lipoprotein, as suggested by Smith *et al.*[2], in the basal region of the pancreas cells. This histochemical work supports a recent hypothesis of Bradbury and Meek (unpublished work) that phospho-lipoproteins are involved in the composition of the membranes of the endoplasmic reticulum.

We would like to acknowledge suggestions arising from valuable discussions with Dr. J. R. Baker and Mrs. A. Przelecka.

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Use of Logarithms in recording Serological Reactions

Vennes, MacDonald and Gerhardt[1] have performed a useful service by pointing out again the potentially misleading effect of comparing serological titres expressed as actual dilutions, and their suggestion that logarithms to the base 2 (or a smaller base for finer work) should be used instead is a good one. I have earlier[2] used powers of 10 in reporting titres obtained by diluting one reagent successively 1 : 10 and, by giving tube numbers[3] merely, what amounted to logarithms to the base 1·5 when dilutions were made in these steps.

My example has not been widely followed; perhaps the suggestion of Vennes, MacDonald and Gerhardt will fare better.

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Electron Microscopy of a Stable *Proteus* L Form

The bacterial L forms, which may arise when normal bacteria are subjected to an unusual or unfavourable environment, are highly pleomorphic: they may consist of granular, vesicular and branched structures. Probably the L forms (reviewed by, among others, Klieneberger-Nobel[1], Dienes and Weinberger[2] and Tulasne[3]) have a structural organization that is different in several respects from that of normal bacteria. Thus some workers[2,3] have described composite structures in L forms consisting of granular elements inside large vesicles. According to Klieneberger-Nobel[4] these granules may fuse with each other. Tulasne[3] assumes that the various morphological structures found in cultures of bacterial L forms represent stages of a complicated life-cycle. This has, however, been questioned by other investigators[5,6]. The observations reported below may be of some interest in connexion with a general discussion of the nature of the bacterial L forms.

The strain used was a stable L form of *Proteus vulgaris*, obtained from Dr. Klieneberger-Nobel[7]. The L form was grown in a liquid medium[8] for 24 hr. at 30° C. with mechanical agitation. After centrifuging the culture the pellets were fixed for 2 hr. at 37° C. in osmic tetroxide vapour. Dehydration and embedding in a methacrylate mixture was performed in the usual way. After polymerization sectioning was carried out on a Sjöstrand ultramicrotome. An RCA type *EMU-2D* instrument was used for the electron microscopy.

The sections revealed spherical or ellipsoidal forms varying widely in size and internal structure. In some preparations vesicles with a rather complex structure were observed (Fig. 1). These vesicles were bounded by an envelope in which sometimes two layers could be distinguished. The layers seemed to consist of chains of minute granules. Moreover, the envelopes surrounded a large number of small bodies of rather uniform size. Similar bodies were found also outside the complex structures.

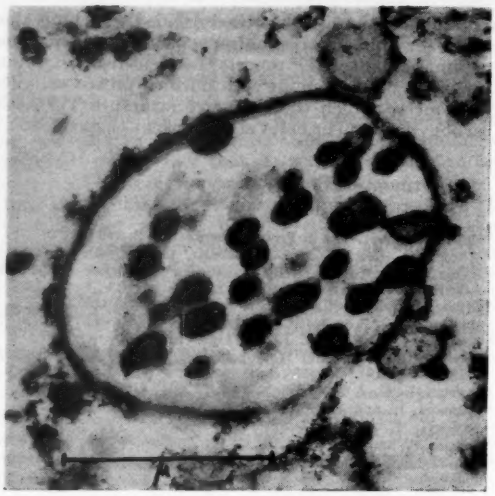

Fig. 1. Thin section of a composite structure found in an electron microscopical preparation of a *Proteus* L form

We are of the opinion that the small bodies found either inside the vesicular structures or free in the medium represent well-defined structural elements and not merely protoplasmic fragments. Similar observations, made using the light microscope[2–4], thus seem to be confirmed. However, it cannot be ascertained by electron microscopy alone whether or not the small bodies shown in Fig. 1 represent stages in the life-cycle of the L form studied.

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Development of *Micrococcus lysodeikticus* Resistant to Lysozyme

Cytochrome *c*-like compounds have been found to be proximate to rat kidney lysozyme in fractions derived from ion-exchange chromatography on 'Amberlite *IRC-50*' resin[1]. This led to experiments designed to test the effects of cytochrome *c* upon bacterial lysis by lysozyme. Although under certain conditions oxidized cytochrome *c* was found to increase the initial rate of lysis by lysozyme, the pigment alone had no antibacterial activity *in vitro*. In testing the potential activity of cytochrome *in vivo*, *M. lysodeikticus* was grown in the presence of lysozyme in very low concentrations (0·1 μgm./ml.) as a control. In this way the production of resistant cells was first observed.

Cultures of *M. lysodeikticus* were originally obtained from the Rutgers Institute of Microbiology and carried

Table 1. GROWTH AND ENZYMIC LYSABILITY OF *M. lysodeikticus* DURING INDUCTION OF RESISTANCE TO LYSOZYME

Passage (μgm. inducer/ml.)		Total growth	Enzymic lysability (enzyme activity per mgm. cell dry weight)	
		$E_{max.}$	10 μgm. lysozyme	20 μgm. lysozyme
1	Control	0·693	8·3	18·9
	0·1	0·622	0·8	1·9
	0·2	—	—	—
2	Control	0·460	12·0	19·6
	0·1	0·512	1·5	2·1
	0·2	—	—	—
3	Control	0·545	9·2	14·5
	0·1	0·760	0·8	1·9
	0·2	0·605	0·7	1·2
4	Control	0·458	9·1	11·3
	0·1	0·702	0·7	1·3
	0·2	0·673	0·3	1·3
5	Control	0·525	6·2	9·4
	0·1	0·464	0·6	0·9
	0·2	0·629	0·8	1·0
6	Control	0·432	3·2	6·4
	0·1	0·517	0·6	1·5
	0·2	0·459	0	0

on an optimal agar medium[2]. Resistant or normal cells were carried on agar slants containing the specific liquid medium with 2 per cent agar added and incubated at 37° C. for 48 hr. before storage at 5° C. Inocula were derived from liquid culture[2] at maximum growth (48 hr., 0·5 ml. adjusted to $E_{660} = 0{\cdot}500$). To measure enzymic lysis, cells were washed with saline twice, extracted with cold acetone and dried with ether[2]. One unit of enzyme activity is defined as an increase of 1 per cent transmission at 545 mμ using a sensitive galvanometer ($2{\cdot}6 \times 10^{-9}$ amp./mm.) in a standard assay system[2] at 25° C. Cell growth was followed using 250 ml. 'Bellco' culture flasks with side-arms made to fit a 'Coleman Jr.' spectrophotometer. Optical density of growing cultures was recorded at 660 mμ.

Resistant cells were produced from normal cells in the presence of lysozyme and studied through six transfers. Rates of growth were measured and the rate of lysis of cell preparations from cultures which had reached maximal growth was determined with 10 and 20 μgm. lysozyme added *in vitro*. Fig. 1 shows results for growth from the first and fifth transfers in a six-transfer experiment with or without 0·1 μgm. crystalline lysozyme (Armour) per ml. of medium. By the fifth transfer the lag phase was eliminated. The course of development of resistance was marked by a decreasing lag period and a stimulation of growth followed by a decrease of total growth

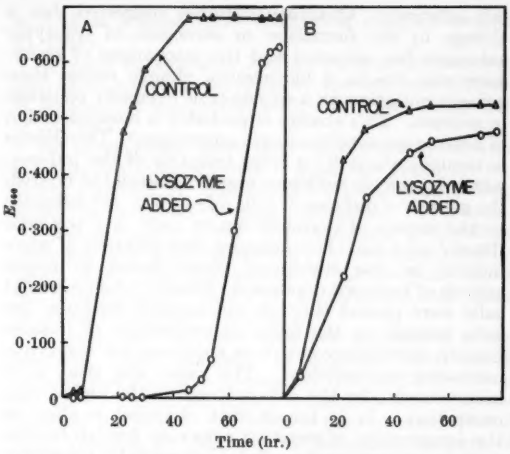

Fig. 1. Growth of *M. lysodeikticus* in presence or absence of lysozyme. *A*, First passage, 0·5 ml. cells of stationary phase ($E_{660} = 0{\cdot}500$) used for inoculum in each case with 10 μgm. lysozyme per 100 ml. Lag phase in presence of lysozyme was generally 48 hr. *B*, fifth passage of the same experiment as in *A* showing loss of lag period. Passages 2–4 showed a gradual decrease of the lag phase in presence of the inducer

of the lower lysozyme level. Live cells, grown through six transfers in the presence of 0·1 or 0·2 μgm. lysozyme/ml., were subjected to lysozyme in suspensions with or without ethylenediamine tetraacetic acid according to Repaske[4]. It was observed that cells with the lower concentration of inducer retained very slight activity for lysozyme while the higher level of inducer produced cells with no measurable activity. Ethylenediamine tetraacetic acid did not reverse the resistance nor was it active alone. The cells remained Gram-positive although the cells with low concentrations of inducer tended to be Gram-negative on ageing; the cells cultured with higher concentration of inducer did not show this tendency. The 0·2-μgm./ml. inducer-level produced white cells after three transfers. We have previously been able to produce cells which were white and inactive as substrate for lysozyme by increasing the relative concentration of carbohydrate in the medium. After six transfers, the affinities of lysozyme for cell preparations were measured using conventional kinetic experiments. Assuming that the enzyme reaction proceeds in a bimolecular fashion:

$$\text{Cell-wall substrate} + \text{En} + \text{Na}^+ \underset{k_2}{\overset{k_1}{\rightleftharpoons}} \text{cell-wall} \cdot \text{Na}^{\text{I}} \cdot \text{En substrate}$$

$$\text{enzyme-substrate complex} \underset{k_4}{\overset{k_3}{\rightleftharpoons}} \text{acetylglucosamine or glucosamine (dialysable)} + \text{residual polysaccharide (non-dialysable)} + \text{En} + \text{Na}^+$$

and reoccurrence of a lag period after the sixth transfer. The results for growth and susceptibility to lysis by lysozyme are shown in Table 1. A 90 per cent decrease in cell lysability is seen after the first passage in the presence of lysozyme (inducer). The slower reduction of the lag period is undoubtedly due to transfer of cells at the stationary phase. Experiments wherein the concentration of the inducer was doubled (0·2 μgm. lysozyme/ml.) produced cells which lost all activity toward lysozyme after five transfers. The growth-curves for this level of inducer were similar to those produced in the presence

and if k_4 is considered to be negligible, the affinity may be estimated by $1/K_s$. Affinities after six transfers were found to be: control cells, 14·3; cells plus 0·1 μgm. inducer/ml., 15·2; and cells plus 0·2 μgm. inducer/ml., 13·1. The corresponding 'Michaelis constants' were found to be: $6{\cdot}98 \times 10^{-2}$, $6{\cdot}58 \times 10^{-2}$ and $7{\cdot}64 \times 10^{-2}$ mgm. dry cells per ml. (the substrate concentration being expressed as dry weight rather than in moles). The affinity of the resistant-cell substrate for the enzyme was not greatly changed, which indicated that the low activity of resistant cells was due to a decrease in available

cell substrate. Qualitative studies suggested that a change in the formation or structure of lysozyme substrate has occurred and the mechanism of resistance was due to a biochemical change rather than genetic mutation or a selection of normally resistant organisms. This change is probably a demonstration of heterogeneous phenotypic adaptation[5]. The change is brought about by a trace quantity of the inducer, which is scarcely sufficient organic material to nourish the growth of millions of cells (about 8×10^8 cells/ml.) to the extent of normally active cells in 1 per cent 'Bacto'-peptone. Furthermore, the addition of more inducer at the stationary phase failed to renew growth of resistant organisms. Finally, when resistant cells were passed through inducer-free medium, the cells trained on the lower concentration of inducer became completely active as substrate for lysozyme, indicating reversibility. The same was true, to a lesser extent, for the cells trained on the higher concentration. It is hoped that chemical studies on the composition of resistant cells may furnish further evidence regarding the cellular substrate for lysozyme.

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Protocatechuic Acid in the Integument of the Silkworm

Since the work of Pryor[1] in 1940, a number of papers have been published on the process of hardening and darkening of insect cuticle after moulting and pupation. According to Pryor, hardening of the insect cuticle is due to the tanning action of an agent produced by oxidation of a phenolic substance. Thereafter, phenols such as protocatechuic acid (3,4-dihydroxy benzoic acid), 3,4-dihydroxyphenyl acetic acid, 3,4-dihydroxyphenyl lactic acid and others have been isolated from various insect cuticles[2].

The occurrence of tyrosine, 3,4-dihydroxyphenyl alanine and 3-hydroxykynurenine has been reported in the silkworm, *Bombyx mori*[3], as well as in other insects, whereas the other phenols remain uncertain. I have now identified the phenolic substances found in the integument of the silkworm.

Phenolic compounds in exuviæ of silkworms at the pupation period were isolated as follows: exuviæ, homogenized in 80 per cent methanol after washing with distilled water, were centrifuged several hours later and the supernatant thoroughly dried under reduced pressure in an atmosphere of nitrogen. The aqueous extract of the dry matter was acidified to Congo red with sulphuric acid, and extracted with peroxide-free ether. The ether extract was shaken with saturated solution of sodium bicarbonate; the bicarbonate part was acidified and extracted with ether, and the ether extract was used for paper partition chromatography. Chromatograms were run at room temperature, and phenols were identified by comparison with pure substances run on the same chromatogram. Tests were made with 1 per cent ferric chloride, Ehrlich's diazo, the ferric chloride/potassium ferricyanide mixture of Barton, Evans and Gardner[4], Riley's phosphomolybdic acid/ammonia[5] and ammoniacal silver nitrate reagents. As solvents, butanol/acetic acid/water (4 : 1 : 1), butanol/ethanol/water (4 : 1 : 1), benzene/acetic acid/water (2 : 2 : 1) and 20 per cent potassium chloride were used. The result is shown in Fig. 1.

Fig. 1. Paper chromatogram of phenolic substances in the exuviæ of silkworms at pupation. Solvent, butanol/ethanol/water (4 : 1 : 1); reagent, ammoniacal silver nitrate. (1) Synthetic protocatechuic acid (Tokyo Kasei Co.); (2) extract of exuviæ of silkworms at pupation

The spot *A* in Fig. 1 was coloured green by ferric chloride and then red by sodium carbonate solution. The spot also instantly reduced ammoniacal silver nitrate, showing that substance *A* was a dihydroxyphenol. The colour reactions were the same as those of synthetic protocatechuic acid and the R_F values of substance *A* corresponded with that of protocatechuic acid in butanol/acetic acid/water (0·80–0·83), butanol/ethanol/water (0·82–0·86), benzene/acetic acid/water (0·05–0·15) and 20 per cent potassium chloride (0·60–0·65). After elution with distilled water from the paper chromatogram, the absorption spectrum of substance *A* was measured with a Beckman spectrophotometer. The eluates showed spectra almost identical with that of protocatechuic acid over the range 220–320 mμ, with maxima at 254 mμ and secondary peak at 288 mμ; this spectrum is clearly different from that of 3,4-dihydroxyphenyl acetic acid. From these results, it is clear that one of the phenolic substances found in the silkworm is protocatechuic acid.

Protocatechuic acid is also found in the integument just before pupation in small quantities. However, when aqueous homogenates of integuments or fresh exuviæ immediately after pupation were incubated at 37° C. for several hours, the protocatechuic acid increased, which suggests that the protocatechuic acid exists in a masked condition or as a precursor. Protocatechuic acid could not be detected in the integuments or exuviæ at other moultings apart from the pupation period.

The soft and colourless pupal cuticles just after pupation turned to a natural amber colour when immersed in protocatechuic acid, but it became purplish black in tyrosine, brown in catechol and pale amber in 3,4-dihydroxyphenyl acetic acid. Thus it appears probable that protocatechuic acid plays an important part in the darkening and hardening of the cuticle of silkworm.

Besides (*A*), another phenolic spot (*B*), was found on the chromatogram, and two more unknown phenolic substances were detected in the crude methanol extract. These phenols will be discussed elsewhere.

I wish to thank Prof. K. Hasegawa for his helpful advice, and Mr. H. Aoki, Department of Agricultural Chemistry, Nagoya University, for the synthesis of 3,4-dihydroxyphenyl acetic acid.

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Effect of Gibberellin and Indoleacetic Acid on Seta Elongation in *Pellia epiphylla*

In Great Britain the sporogonium of *Pellia epiphylla* is fully differentiated into foot, seta and capsule by the end of September. Under natural conditions elongation of the seta, resulting from the extension of its individual cells, does not take place until the following year, usually from late February onwards. Elongation appears to follow the maturation of the spores of which external indication is given by a darkening of the capsule wall. During a period of not more than 3–4 days the seta elongates from 1 mm. to upwards of 80 mm.

Wagner[1] has suggested that the stimulus for elongation comes from the capsule and that it originates from the production of auxin during, or following, spore production.

In January, plants of *Pellia epiphylla*, bearing 25 sporophytes with mature capsules but non-elongated setæ, were placed in Petri dishes and sprayed with a solution of 100 p.p.m. potassium gibberellate ('Gibrel', Merck), to which a little wetting agent had been added. Controls were sprayed with water. All plants were kept at 18° C. and exposed to natural daylight and day-length for this period of the year. In all treated plants full seta elongation occurred and reached an average length of 57 mm. after 5 days. The controls were unaffected.

An experiment was also performed with twenty-four intact sporogonia which had been dissected from the thallus. All those treated with potassium gibberellate showed a slight elongation (7–10 mm.), the controls being unaffected. To these excised sporogonia was now added a solution of 1·0 p.p.m. of indoleacetic acid. In all the sporogonia treated with both substances full elongation of the setæ occurred (average length, 63 mm.). Those treated with indoleacetic acid alone showed some elongation (average length, 37 mm.).

Previous experiments had shown that indoleacetic acid alone added to the isolated dormant sporophyte, or sprayed on the intact plant, stimulates elongation of the seta.

We have shown, then, that the dormant seta may react in the following way: (*a*) intact plant (sporophyte attached to gametophyte), potassium gibberellate or indoleacetic acid stimulates elongation; (*b*) isolated sporophyte, (1) potassium gibberellate produces only slight elongation (7–10 mm.), (2) indoleacetic acid following potassium gibberellate gives full elongation (63 mm.), (3) indoleacetic acid alone produces elongation (37 mm.).

If we accept the idea that cell elongation is dependent, either partially or entirely, upon auxin supply, and this is supported by (*b*2) and (*b*3) above, it must be concluded that the dormant seta contains little or no auxin. In Nature the dormant period from October to February is then due, in part at least, to the absence of auxin. Furthermore, it would appear that the gametophyte is capable of producing auxin or some precursor by January at least, since upon addition of potassium gibberellate full seta elongation follows. This experiment seems to cast some doubt upon the validity of the supposition that the auxin required for seta elongation in Nature is necessarily derived from the capsule. Similar results to the above have been obtained in experiments on the intact plants of other liverworts.

The experiments with the intact plant lead to speculation as to the nature of the factors governing the dormancy of the cells of the seta. One possibility, but we think an unlikely one, is that auxin is present in the thallus but is unable to diffuse to the seta during the dormant period unless some growth-regulator of the gibberellin type is present. An alternative explanation is that the potassium gibberellate acts on the cells of the thallus by removing an auxin inhibitor, or by activating an auxin precursor (cf. ref. 2). There is, however, some evidence that treatment of the excised sporophyte with indoleacetic acid alone produces less elongation than indoleacetic acid and potassium gibberellate—an average of 37 mm. as compared with 63 mm. respectively. Further experiments are in progress to check on this point.

Pellia differs from other members of the Jungermanniales in that division of the spores occurs prior to their discharge from the capsule. Those sporogonia which had been treated with gibberellin developed rhizoidal outgrowths from the multicellular spores. In Nature this does not occur until after spore dispersal.

So far as we are aware, this is the first report of a response by liverworts to gibberellin. A full account will be given elsewhere. We are indebted to Merck and Co. for presenting the 'Gibrel' used in these experiments.

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Embryological Investigation in *Hibiscus sabdariffa* × *H. cannabinus* and their Reciprocal Crosses

Previous attempts to hybridize between the two commercially important fibre-yielding species of *Hibiscus*, namely, *H. cannabinus* L. ($2n = 36$) and *H. sabdariffa* L. ($2n = 72$) by different workers[1-4] have all resulted in the production of non-viable seeds only. These workers considered that the outlook for interspecific hybridization between these two species was not promising. However, in a recent study of pollen-tube growth *in vivo* in the crosses between these two species (*cannabinus* × *sabdariffa* and vice versa), I recorded a reciprocal receptivity of pollen germination and growth in the stylar region, indicating that no stylar incompatibility is involved in those crosses[5].

A further investigation of the embryology of these crosses was therefore undertaken and the results so far obtained are reported here.

The embryological materials were fixed in Navaschin's fluid at different hours of pollination. Only the dissected ovaries were fixed for the purpose. The materials were subjected to normal microtomic procedures. The sections were cut at 12μ thickness and stained in Heidenhain's iron-alum-hæmatoxylin.

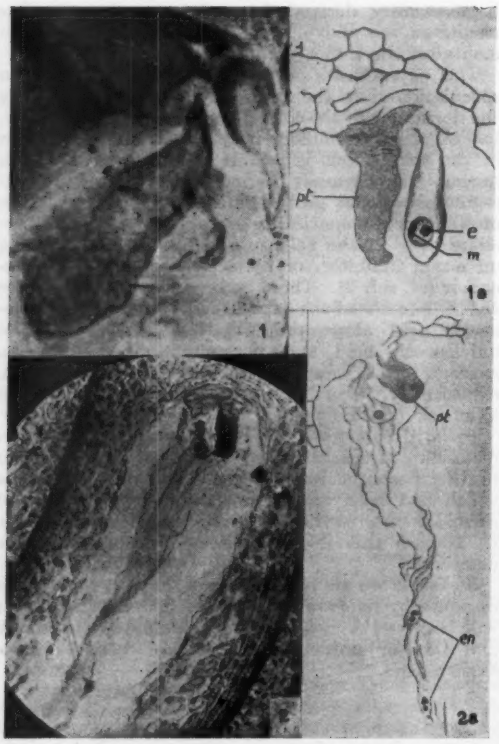

Fig. 1. Photomicrograph and (1*a*) camera lucida drawing of the section through the micropylar end of the embryo sac of *H. cannabinus* (crossed with *H. sabdariffa*) showing the fertilization of egg cell, one degenerating synergid and the remnant of pollen tube

Fig. 2. Photomicrograph and (2*a*) camera lucida drawing of the section through the portion of the embryo sac in *H. sabdariffa* × *H. cannabinus* cross (24 hr. after pollination) showing two endosperm nuclei with symptoms of degeneration

e, Egg nucleus; *en*, endosperm nuclei; *m*, male nucleus; *pt*, pollen tube. (× 60)

In both *sabdariffa* × *cannabinus* and their reciprocal crosses, a normal type of porogamous fertilization was observed in the materials fixed twenty-four hours after pollination. In *cannabinus* × *sabdariffa*, one of the male gametes was observed in the state of fusion with the egg nucleus (Figs. 1, 1*a*), whereas in the *sabdariffa* × *cannabinus* cross the development of the endosperm was noticed (Figs. 2, 2*a*). In the latter case, the endosperm was in the two-nucleate condition and each nucleus contained two large and one small nucleoli. From the preparation it seems that the two free nuclei of the endosperm were in the stage of degeneration.

These observations were also verified from the embryological study in the controls (ovaries of selfed flowers of *cannabinus* and *sabdariffa* fixed twenty-four hours after pollination) where the normal porogamous fertilization and the consequent development of endosperm seemed to be earlier as the endosperm was observed to consist of many free nuclei. The development of the zygote seemed to be very belated, and twenty-four hours after pollination it showed no signs of activity.

It is suggested from the above observation that in the cross between the two fibre-yielding plants of *Hibiscus* (*cannabinus* and *sabdariffa*) the non-setting of seeds is not due to failure of fertilization. It may further be inferred that the cause of non-setting of seeds is most likely to be some sort of 'somatoplastic sterility'. A detailed study on further development of the embryo and endosperm is in progress.

I wish to thank Dr. B. C. Kundu, director, Jute Agricultural Research Institute, under whose guidance the present investigation was carried out for the D.Phil. degree of the University of Calcutta.

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Control of Turnip and Cabbage Mildew (*Erysiphe polygoni* DC.) by Zinc

Susceptibility of plants to powdery mildew diseases is well known to be affected by nutrition. In water-culture experiments with various plants, high concentrations of boron[1], cadmium[2], copper[3], lithium[4], manganese[5] and silicon[6] have been reported to reduce infection. Cherewick[7] found, however, that when these chemicals were added to the soil they had no effect on the severity of wheat mildew (*Erysiphe graminis* DC.).

Bolle-Jones and Hinton[8] reported that rubber plants (*Hevea brasiliensis*) grown in sand and fed with culture solutions deficient in zinc became heavily infected with mildew (*Oidium heveae*), whereas, when fed with solutions containing 0·065 p.p.m. zinc, they remained almost free from the disease.

Investigations have been made by us on the effects of the addition of zinc to the soil on the powdery mildews of turnip and cabbage caused by *E. polygoni*. The plants were grown in a glasshouse in pots of soil either containing various proportions of zinc fritted glass[9] (zinc frit) or watered with solu-

Table 1. Effect of Zinc Frit on Turnip Mildew

Soil treatment	No. of days from inoculation	No. of plants	No. of leaves	Percentage of leaves with following areas mildewed					
				None	Trace–1/16	1/16–1/8	1/8–1/4	1/4–1/2	> 1/2
Control	34	10	91	41·6	25·4	9·9	7·7	8·8	6·6
0·1 per cent frit	34	9	98	42·9	20·4	7·1	8·2	14·3	7·1
1·0 per cent frit	34	10	97	73·2	18·6	4·1	2·1	1·0	1·0
10·0 per cent frit	34	7	37	97·6	2·4	0·0	0·0	0·0	0·0
Control	62	10	142	8·5	3·5	1·4	3·5	4·9	78·8
0·1 per cent frit	62	10	144	3·5	6·2	0·7	4·8	3·5	81·3
1·0 per cent frit	62	10	144	19·4	4·1	0·7	6·3	18·8	50·7
10·0 per cent frit	62	5	48	81·2	10·4	2·1	4·2	2·1	0·0

tions of zinc sulphate. The plants were inoculated by depositing spores of *E. polygoni* on their upper leaf surfaces at the rate of 0–1·5 spores per mm.^{2}. The proportion of the leaf surface covered by the mildew was estimated with the aid of a standard key diagram.

In the tests with zinc frit, mildew rapidly developed 34–62 days after inoculation on the leaves of turnips grown in untreated soil, but infection was considerably less in the same period on the plants grown in soil with 1·0 and 10·0 per cent w/w zinc frit (Table 1). Plants grown in soil containing 0·1 per cent w/w zinc frit were as much infected as the control plants 34–62 days after inoculation. Plants grown in soil with 1·0 per cent zinc frit were less infected in 5 in. than in 3 in. pots. Plants grown in soil with 10·0 per cent zinc frit became chlorotic and stunted, but those in 0·1 and 1·0 per cent zinc frit showed no such effects.

The zinc content of the leaf fresh-matter of untreated plants and plants grown in soil containing 0·1 and 1·0 per cent zinc frit was 2·3, 5·5 and 21·8 p.p.m., respectively. This suggests that the suppression of mildew was caused by the absorption of zinc by the plant from the soil and its accumulation in the leaves.

In a second experiment turnips were grown in untreated soil, in soil containing 1·0 or 2·0 per cent zinc frit, and in soil watered with solutions of zinc sulphate containing 500 p.p.m. zinc. Plants in the untreated soil had become heavily mildewed after 63 days, but those in all the treated soils remained only very slightly infected.

In a third test, heavily mildewed, 8-week-old turnip plants were watered with (1) demineralized water, (2) zinc sulphate solution containing 100 p.p.m. zinc, and (3) zinc sulphate solution containing 500 p.p.m. zinc. Five weeks later, the plants receiving 500 p.p.m. zinc developed new leaves which remained uninfected, whereas the new leaves on the plants in the other two treatments became heavily infected. This effect continued for five months and, as the old leaves dropped off, the plants receiving 500 p.p.m. zinc became completely healthy (Fig. 1).

The results obtained with cabbage powdery mildew were similar to those reported above. The addition of zinc frit to the soil at the rates of 1·0 and 10·0 per cent w/w gave a great reduction in disease, but the use of 0·1 per cent w/w zinc frit did not. The fresh matter of the untreated plants and plants grown in soil containing 0·1 and 1·0 per cent zinc frit contained 1·2, 3·0 and 14·7 p.p.m. zinc, respectively.

Zinc frit and zinc sulphate were applied to soil in which cucumber, chrysanthemum and vegetable marrow plants were grown but the treatments caused no reduction in the amount of mildew (*E. cichoracearum* DC.). Analyses showed that the leaves of the treated plants contained more zinc than those of the untreated plants and it thus seems possible that *E. cichoracearum* is more tolerant than *E. polygoni* to high zinc concentrations in the leaves.

Full details of this work will be published elsewhere.

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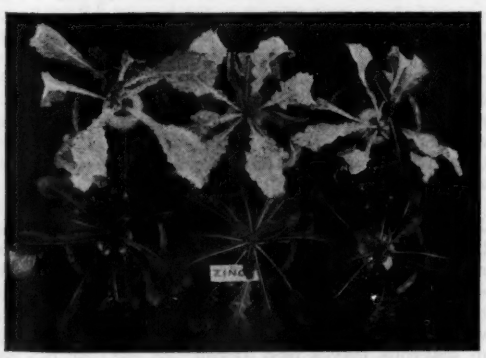

Fig. 1. Upper row: Untreated plants, heavily mildewed. Lower row: Plants receiving zinc sulphate twice weekly for 16 weeks. Approximately 2·5 gm. zinc applied to each plant

Chromosome Number in the Silver Fox (*Vulpes fulvus* Desm.)

Two male silver foxes were killed by electrocution on February 1. The testes were teased in distilled water, where they remained for 10 min., and then the pieces were put into aceto-orcein and temporary slides were made by the usual squash methods.

The testicular material under observation contained numerous spermatogonial cells undergoing division. Care was taken to count the chromosomes only in those cells that seemed to be intact and had the chromosomes well spread. From the mitotic metaphase plate it was clearly seen that the diploid number of chromosomes was 38 (Fig. 1*a*).

By examination of the morphological character of the individual chromosomes I found fourteen pairs with metacentric or submetacentric centromeres,

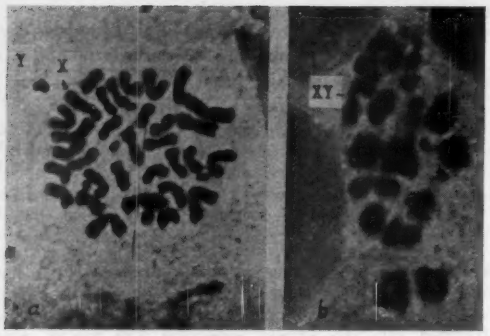

Fig. 1. [Chromosomes of the silver fox (*Vulpes fulvus*): (*a*) mitotic metaphase with 38 chromosomes. The *X* and *Y* chromosomes are indicated; (*b*) first mitotic metaphase with 19 bivalents. The *X*–*Y* complex is indicated. The dot-like chromosomes have already separated. (× 1,600)

five chromosomes with teleocentric centromeres and five dot-like chromosomes in striking contrast to the others in shape. It is assumed that one of the teleocentric and one of the dot-like chromosomes represent the sex chromosomes.

Counts from the primary and secondary spermatocyte division confirmed the number given. The first meiotic metaphase contained nineteen ordinary bivalents and one element with a heteromorphic structure which was thought to be the *X*–*Y* complex (Fig. 1*b*).

The results obtained in this investigation indicate that the diploid chromosome number in the male silver fox (*Vulpes fulvus*) is 38. This is not in agreement with Wodsedalek[1], who reported 42, and Bishop[2], who gave 32 as the diploid number. It seems that *Vulpes vulpes* and *Vulpes fulvus* have the same number of chromosomes[3]. The karyotypes of the two species also seem to be similar to one another.

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Detection of Tsetse Fly at Night

Paints which fluoresce in ultra-violet light were found promising in the laboratory for marking *Glossina*[1]. A test to confirm the usefulness of the method in the field was made in January 1957, with *Glossina swynnertoni* Austen, at Shinyanga, Lake Province, Tanganyika.

Flies were caught, fed, marked with fluorescent paint and released during the day. At dusk on the same day marked flies were observed on the boles of trees and on the underside of horizontal branches. After dark, with ultra-violet light, flies could not be found in the positions in which they had been observed previously. Subsequent search in ultra-violet light revealed sixteen flies, all on leaves, fourteen on the top and two on the underside; all shone brilliantly in the ultra-violet beam.

Further search failed to reveal any flies on the boles or branches of trees; it would appear, therefore, that these are only daytime resting sites and that at night *Glossina* rest on leaves.

G. R. Jewell

East African Trypanosomiasis
Research Organization,
Tororo, Uganda.
March 12.

[1] Jewell, G. R., *Nature*, **178**, 750 (1956).

Use of Reflecting Paints for locating Tsetse Fly at Night

Tsetse have been successfully marked, so that they can be located at night, with paints which fluoresce in ultra-violet light[1] (see Jewell, preceding communication), but the method had the disadvantage that the equipment required to produce ultra-violet light in the field was cumbersome. It was considered that the reflecting paints, nowadays widely used for road signs, might be equally effective for marking the insects and require only light in the ordinary visual range, such as can be provided by an electric torch.

The reflecting action of these materials seems to depend on their containing microscopic glass beads. Preliminary experiments with an aerosol form of the paint (Codit No. 7211 Reflective Paint; Minnesota Mining and Manufacturing Company, 900 Bush Avenue, St. Paul, 6, Minnesota) showed that spots 0·7 mm. in diameter on black paper could be seen and photographed at 5 m. distance in the light of a 12-V. torch. Spots 1 mm. in diameter on pinned tsetse could be seen with ease at 10 m.

The toxicity of the aerosol paint to tsetse was not tested; the aerosol form is in any event unsuitable as it is liable to foul the wings and other organs. Instead, further experiments were conducted with the glass beads themselves in more easily applicable media. Mixed with artist's megilp, the material usually employed for marking tsetse[2], the beads lost their reflectivity, but in a thin varnish of shellac in alcohol or a gum acacia solution with a trace of detergent ('Teepol') the reflexion produced was as brilliant as that given by the aerosol form.

A small field trial of the gum acacia mixture was carried out in tsetse habitat at Lugala, Busoga, Uganda. Fifty-six *Glossina pallidipes* were marked on the thorax with spots about 2 mm. in diameter. The tsetse were released at dusk on the edge of a square thicket, 0·2 hectare in area, enclosed by a fence of thorn and wire 2 m. in height. Searching, by three people with 12-V. torches, was begun as soon as the flies had been released. The thicket was examined at close quarters for the first hour and only one fly was found. The searchers then moved 9 m. away from the thicket edge; reflexion from leaves was then reduced, and nine marked tsetse were located in about half an hour, some on bushes searched earlier at close quarters.

The reflexions from the spots of paint were distinctive and brilliant at that distance and could be distinguished from other reflecting bodies such as insect ocelli by their size and colour. It was important to hold the torch close to the eyes to obtain the maximum reflecting action. All but the first fly found, which was under a twig, were resting facing upwards on glabrous leaves (see Jewell, *loc. cit.*) at heights between 2·5 and 4 m. above the ground. Most of the flies were found near where they had been released,

but two were nearly 20 m. away; it is possible that many flies, particularly those released before it was really dark, left the enclosed area and settled outside.

It is considered that these reflecting paints have great possibilities as a means of detecting resting tsetse at night; they appear more effective than fluorescent paints and avoid the necessity for ultra-violet light. As the spots required are small, the method is possibly of application for other insects smaller than tsetse, perhaps even mosquitoes.

We are indebted to Mr. J. A. Kidd of the British East Africa Corporation, Nairobi, for his ready help in obtaining for us the materials used in this work.

B. D. Rennison
W. H. R. Lumsden
C. J. Webb

East African Trypanosomiasis
Research Organization,
Tororo, Uganda.
March 13.

[1] Jewell, G. R., *Nature*, 178, 750 (1956).
[2] Jackson, C. H. N., *Bull. Ent. Res.*, 21, 491 (1930).

Agrotype Concept in Chemical Analysis of Tea

Several observations at Tocklai suggest that the ratio of chemical elements and compounds to total dry matter of the tea plant (*Camellia sinensis* L.) may often bear a relation to the agrotypes defined by calcium oxalate crystals and crystal-cells described in an earlier communication[1]. The frequency of cells that can contain crystals is limited genetically, but the number of cells that actually contain crystals (druses) varies within those limits. We use the term 'crystal-cells' to designate cells that can contain crystals but may or may not do so. By 'crystals' we mean cells that do in fact contain crystals.

The potassium content of genotypically different tea plants can be correlated with crystal frequency. This is illustrated in Fig. 1, in which the ordinates are potassium oxide as per cent dry weight of the leaf, plotted against crystal frequency per petiole. The data are group means, the five points being based upon 3, 10, 11, 3, 1 bushes respectively.

As the possible crystal frequency is within genetic limits, Fig. 1 suggests that a potassium content due to treatment could be considered high or low only by reference to the mean potassium content of the group. This mean could be considered normal. It is a function of crystal frequency. Thus by reference to that frequency the potassium content of plants of unknown origins growing together under similar conditions could be more logically compared one with another; for example, large differences of crystal frequency would be likely to indicate real differences of normal potassium content.

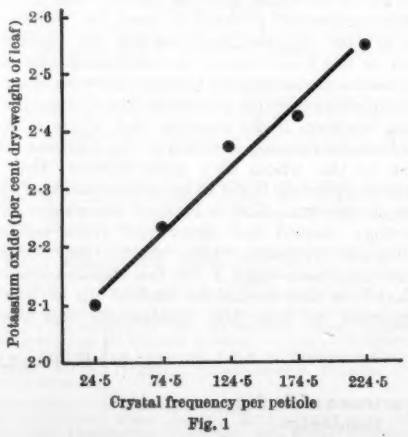

Fig. 1

The ease with which crystal frequency can be observed, and its association with nutrient uptake[2,3], make it of special value for the study of agricultural problems. Environmentally induced variation of potassium content is likely to be negatively correlated with variation of crystal frequency[3]; but analysis of co-variance might show potassium to be lower than expected from an observed crystal increase, or to be higher than expected from an observed reduction of crystals. The former condition might be indicative of a potassium deficiency and the latter of a luxury uptake.

The simple genetical behaviour of crystal-cell frequency makes it convenient to regard chemical composition as primarily dependent upon this cell frequency, and to be secondarily influenced by physical factors of the environment. This interpretation is supported by the positive genetic relation between calcium crystals and potassium content.

Apart from the possibility of special techniques, such as the injection procedure suggested by Barua[3], observation of crystal and crystal-cell frequency could lead to a better understanding of chemical analysis. Potassium has been used as an example, but similar arguments are likely to apply to calcium, or to compounds such as the rhamnodiglucosides of quercetrin and kaempferol[4], or to the subjective attributes of flavour and quality of the made tea.

I am indebted to Dr. E. A. H. Roberts for the potash determinations, and to the Director of Tocklai and the Indian Tea Association for permission to publish this work.

W. Wight

Scientific Department,
Indian Tea Association,
Tocklai Experimental Station,
Cinnamara.
March 18.

[1] Wight, W., *Nature*, 181, 893 (1958).
[2] Wight, W., and Barua, P. K., *Curr. Sci.*, 23, 78 (1954).
[3] Barua, D. N., *Curr. Sci.*, 25, 249 (1956).
[4] Roberts, E. A. H., Wight, W., and Wood, D. J., *New Phytol.* (in the press).

Static Sense of *Calliphora* and the Physical Stabilizing Effect of the Halteres

In his book "Insect Flight"[1], Dr. J. W. S. Pringle imputes to me faults I have not committed and assertions I have not made.

1. On pp. 107–108 he writes: "A change in the pattern of wing movements during static tilts of $\pm 45°$ in the pitching and rolling planes has been claimed by Schneider (1953) from experiments in which the downflow of air from a tethered flying *Calliphora* was indicated by the pattern of displacement of lycopodium powder on a card. The effects were, however, also shown to a lesser extent in anæsthetic flight, and unfortunately figures are not given of the magnitude of the change in the normal insect and the control."

In the paper[2] quoted I wrote, that for the statistical evaluation of the powder pattern only such charac-

teristics were used as were not changed in the control. The figures for the means, for their standard errors, and for the probabilities of the null hypotheses (*t*-test) are specified in the paper[2].

2. Discussing these same experiments Dr. Pringle writes on p. 108: "Schneider's (1953) claim to have demonstrated a static sense mediated by the halteres of *Calliphora* has already been criticized, . . ."

I never claimed to have demonstrated a static sense mediated by the halteres. As explicitly stated in the paper[2], for the investigation of a static sense I examined flies the halteres of which were removed 3 days before the experiments. Therefore I could not claim that the halteres mediate a static sense. On the contrary, I emphasized that the receptors responsible for the observed reactions are not yet known.

3. On p. 109 Dr. Pringle describes the experiments I made which suggest a physical stabilizing effect of the halteres. He states, correctly: "The conclusion from these results, that there is a direct physical action of the halteres on the movements of the wings, relies on the assumption that haltere reflexes are absent in 'anaesthetic flight' and that the heat treatment had destroyed all sensory function."

If one of these assumptions is true, the physical stabilizing effect of the halteres is proved. To my way of thinking my experiments demonstrate that both assumptions are very probable and that it would be difficult to find grounds for assuming the contrary.

Dr. Pringle has, however, ignored the probability of the assumptions. When he argues: "The reasoning is unconvincing in view of the extreme physical difficulties of a possible mechanism. Pringle (1948) showed that the mass of the halteres is about 0·04 per cent of the mass of the fly, so that a direct gyro-stabilizing effect is out of the question," the reader is given the impression that in my paper[2] I have suggested a direct gyro-stabilizing effect of the halteres.

This is not true. On the contrary, I denied this hypothesis with the same argument as Dr. Pringle has used. Furthermore, when he states in the next sentence: "Only by a form of servomechanical influence on the force-transmission mechanism in the basal wing articulation could a direct physical influence operate, . . .", he is concurring with the suggestion made in my paper[2]. For my experiments have demonstrated a close physical interaction between the motions of the wings and of the halteres of a flying *Calliphora*.

Continuing, Dr. Pringle states: ". . . and the anatomy of the fly does not suggest that such a mechanism is present".

Here is the sole argument that remains. I find it a weak argument to state, in the face of physiological evidence, that the morphological basis is not yet known. Between the regions of the haltere base and of the wing articulation there are, however, movable sclerites as a possible anatomical substratum for the suggested mechanism. Dr. Pringle himself has described "a mechanical interaction between the two systems" (namely, the halteres and the wings)[3].

G. Schneider

Zoologisches Institut der
Universität Würzburg,
Röntgenring 10.

[1] Pringle, J. W. S. (Camb. Univ. Press, 1957).
[2] Schneider, G., *Z. vergl. Physiol.*, **35**, 416 (1953).
[3] Pringle, J. W. S., *Phil. Trans. Roy. Soc.*, B, **233**, 347 (1948).

I must apologize to Dr. Günter Schneider if I have inadvertently mis-interpreted some of his experiments in my book. I have the greatest respect for his skill as an experimenter, and have acknowledged that his 1953 paper widens considerably our knowledge of the functions of the halteres of Diptera. In his communication Dr. Schneider objects to three passages in my book. The second of these I admit is in error; he does not claim that the halteres mediate static reflexes. I was misled by the summary at the end of his paper in which, having stated that static sense organs are present and that compensatory wing movements occur to rotations about the vertical axis, he continues "These reactions are mediated by the compound eyes, halteres and antennæ (and perhaps by other sense organs responding to the air-flow)".

The first and third criticisms, to which Dr. Schneider objects, I cannot altogether withdraw, but I should, perhaps, have made them more precise.

1. His evidence for a static sense is derived from comparison of the shape of the powder patterns (pterograms) produced by the down-wash of air from a flying fly when it is placed in various attitudes. Some differences are found in the patterns when the fly is performing what is known as 'anæsthetic flight', and these are reasonably ascribed to direct aerodynamic effects, since reflexes are supposed to be absent in this condition. As evidence for a reflex effect in normal flies, Dr. Schneider considers one particular measurement of the pterogram, its fore-and-aft length, and shows that the results are statistically significant as between flies tilted to the left and to the right. This effect is said to be absent in anæsthetic flight, but we are not given a similar statistical treatment of the same measurements in the controls. Even accepting this, however, it remains true that the wing movements of anæsthetic flight have never been shown to be identical with those in a normal insect, and it cannot, therefore, be excluded that this effect also is a direct aerodynamic one.

3. A purely physical, non-reflex stabilizing effect from the halteres is the most startling of Dr. Schneider's claims. I was, of course, well aware that he did not support the old mass-balance theory, which is clearly impossible in the light of measurements of the mass of the haltere; I do not think that the sentence in my book gives a false impression. I could not find room for a full discussion of his evidence for some form of servo-mechanical control, but hoped to stimulate interested persons to read Dr. Schneider's paper in the original and decide for themselves whether or not his evidence is convincing. In effect, he postulates a mechanical linkage between the bases of the halteres and wings so precise that the mechanical coupling between flight muscles and wings is varied by the Coriolis forces generated in the halteres during rotation of the whole fly: and, further, that this operates to stabilize flight in all three planes of space. I agree, in general, that a lack of knowledge of the morphology should not deter one from accepting physiological evidence, but when that evidence itself is not water-tight I do feel that a claim as remarkable as this should be backed up at least by a suggestion of how the mechanism can operate physically.

J. W. S. Pringle

Department of Zoology,
Cambridge.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 12

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Academician J. P. Gerasimov: "Land Use and Contemporary Geography in the U.S.S.R.".

ROYAL INSTITUTION, LIBRARY CIRCLE (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Mr. W. H. Langwell: "How Does Air Pollution Affect Books and Paper?"

Monday, May 12—Thursday, May 15

CROP PROTECTION AND PEST CONTROL EXHIBITION (at the Royal Horticultural Society's New Hall, Westminster, London, S.W.1).

Tuesday, May 13

ROYAL METEOROLOGICAL SOCIETY (joint meeting with the NATIONAL SOCIETY FOR CLEAN AIR, at Agricultural House, Knightsbridge, London, S.W.1), at 4.30 p.m.—Mr. C. J. Regan: "Progress in Atmospheric Pollution Research"; Dr. W. C. Turner: "The Introduction of Smoke Control Areas"; Mr. R. G. Veryard: "Climatological Aspects of Air Pollution"; Mr. N. G. Stewart: "Radioactivity in the Atmosphere—Its Origin and Measurement".

UNIVERSITY OF LONDON (at the London School of Economics and Political Science, Houghton Street, London, W.C.2), at 5 p.m.—Dr. Abel Smith: "Social Security".* (Sixteenth of a series of lectures on "Law and Opinion in England in the Twentieth Century". Further lecture on May 20.)

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (at the Courtauld Institute of Art, 20 Portman Square, London, W.1), at 5.30 p.m.—Dr. J. Shearman: "Leonardo's Position in the History of Colour in Florence".

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. D. T. Turner: "Grafting on Rubber by High Energy Irradiation".

Wednesday, May 14

INSTITUTE OF PHYSICS, STRESS ANALYSIS GROUP (at 47 Belgrave Square, London, S.W.1), from 10 a.m. to 6 p.m.—Meeting on "Contact Stresses".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Sir Ian Heilbron, D.S.O., F.R.S.: "Expanding Horizons in Organic Chemistry" (Pope Memorial Lecture).

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—General Meeting.

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Sir Keith Murray: "The Development of the Universities in Great Britain".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. D. Gabor, F.R.S., Mr. P. R. Stuart and Mr. P. G. Kalman: "A New Cathode-Ray Tube for Monochrome and Colour Television".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Annual General Meeting, followed by an address by Sir Harry Jephcott.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. Edward Ironmonger: "The Royal Institution and the Teaching of Science in the Nineteenth Century".

Thursday, May 15

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 4 p.m.—Annual General Meeting.

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5 p.m.—Annual General Meeting. 6.30 p.m.—Mr. D. G. Fink: "Recent Developments in Electronics in the United States".

LONDON MATHEMATICAL SOCIETY (at the University, Bristol), at 5 p.m.—Prof. H. Hopf: "Are Spheres the Only Closed Surfaces with Constant Mean Curvature?",

ROYAL ANTHROPOLOGICAL INSTITUTE OF GREAT BRITAIN AND IRELAND (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Dr. Raymond Cabannes: "The Distribution of Abnormal Hæmoglobins in Algeria, Hoggar and High Volta".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. G. W. H. Gardner, C.B., C.B.E.: "Automatic Flight—The British Story" (46th Wilbur Wright Memorial Lecture).

BRITISH INSTITUTE OF RADIOLOGY, incorporated with the Röntgen Society (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 7.30 p.m.—Annual General Meeting. 8 p.m.—Ordinary Meeting followed by Prof. F. S. Dainton, F.R.S.: "Radiation Chemistry in Retrospect and in Prospect" (Thirty-seventh Silvanus Thompson Memorial Lecture).

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. J. R. Audy: "The Localization of Disease, with special reference to the Zoonoses".

UNIVERSITY OF LONDON (at Wye College, near Ashford, Kent), at 8.15 p.m.—Prof. J. Horring (Landbouw-Economisch Instituut, Netherlands): "Dutch Agriculture; its Economic Structure and Problems".*

Friday, May 16

INSTITUTE OF NAVIGATION (at the Royal Geographica Society 1 Kensington Gore, London, S.W.7) at 5.15 p.m.—Mr. E. W. Anderson, O.B.E., "The Principles of Inertia Navigation Systems".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Annual General Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN BIOCHEMISTRY in the Department of Biochemistry and Chemistry—The Secretary, Royal Free Hospital School of Medicine (University of London), Hunter Street, London, W.C.1 (May 17).

LEVERHULME FELLOW AND LECTURER (with a good knowledge of high energy nuclear physics) IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Liverpool (May 17).

POSTGRADUATE RESEARCH STUDENT IN ARCHÆOLOGY—The Registrar, The University, 36 North Bailey, Durham (May 23).

ASSISTANT LECTURER (preferably with a special interest in inorganic chemistry) IN CHEMISTRY—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (May 24).

GRADUATE RESEARCH ASSISTANT, and a TECHNICAL RESEARCH ASSISTANT IN PLANT PATHOLOGY—The Registrar, University College, Singleton Park, Swansea (May 24).

ASSISTANT LECTURER (with an honours degree in physics or equivalent qualification) IN PHYSICS at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, May 30).

READER IN APPLIED THERMODYNAMICS at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 30).

DEMONSTRATOR (with special qualifications in bacteriology or microbiology) IN THE DEPARTMENT OF BOTANY—The Registrar, The University, Nottingham (May 31).

HOLLERITH RESEARCH STUDENT (suitable qualified graduate or prospective graduate) IN THE DEPARTMENT OF NUMERICAL AUTOMATION—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (May 31).

LECTURER (Grade II) (preferably with some experience of university teaching) IN PHYSICS—The Registrar, The University, Bristol 8 (May 31).

LECTURER (honours graduate in physics or chemistry) IN TEXTILE CHEMISTRY—The Registrar, The Manchester College of Science and Technology, Manchester 1 (May 31).

LECTURER IN STATISTICS in St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (May 31).

RESEARCH ASSISTANT (with an honours degree in botany and training in cytology and/or genetics) IN THE DEPARTMENT OF BOTANY—The Registrar, The University, Liverpool (May 31).

ASSISTANT LECTURER (preferably with research experience) IN MATHEMATICS, and an ASSISTANT LECTURER (with a special interest in some aspect of parasitology) IN THE DEPARTMENT OF AGRICULTURAL AND FOREST ZOOLOGY—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (June 2).

READER IN PHARMACEUTICS at the School of Pharmacy—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 3).

SUPERINTENDING TECHNICIAN or SENIOR TECHNICIAN IN THE DEPARTMENT OF PHARMACOLOGY, University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 10).

SENIOR LECTURER (preferably with research experience in the fields of comparative physiology and biochemistry or entomology) IN ZOOLOGY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 30).

ASSISTANT LECTURER, Grade B (with experience in some aspects of industrial instrumentation such as high temperature, fluid flow, or pressure measurement and control, etc., and preferably with a degree or higher national certificate, including physics), IN THE PHYSICS DEPARTMENT—The Principal, North Staffordshire Technical College, Stoke-on-Trent, Staffs.

ASSISTANT LECTURER, Grade B (with a degree or equivalent qualification, and preferably teaching and industrial experience), IN THE SCIENCE DEPARTMENT, Thurrock Technical College, Woodview, Grays, to teach mainly physics and chemistry up to higher national certificate standard—The Clerk to the Governors, Divisional Educational Office, Upminster Court, Hall Lane, Upminster, Essex.

ASSISTANT LECTURER or LECTURER IN PURE AND/OR APPLIED MATHEMATICS—The Secretary of the Trustees, Magee University College, Londonderry, Northern Ireland.

ASSISTANT PROFESSOR OF METALLURGY—The Chairman, Department of Metallurgy, Vanderbilt University, Nashville, Tennessee, U.S.A.

ELECTRONIC ENGINEER (with a good honours degree or equivalent) to develop sensitive equipment for measuring ionizing radiations and radioisotopes—The Director, Radiological Protection Service (M.B.C. and Ministry of Health), Clifton Avenue, Belmont, Sutton, Surrey.

LECTURERS and ASSISTANT LECTURERS IN ELECTRICAL ENGINEERING; a LECTURER and an ASSISTANT LECTURER IN PRODUCTION ENGINEERING; a SENIOR LECTURER IN INSTRUMENT TECHNOLOGY; a SENIOR LECTURER, LECTURERS and an ASSISTANT LECTURER IN MATHEMATICS; a READER, SENIOR LECTURERS and ASSISTANT

LECTURERS IN APPLIED PHYSICS; and a READER IN INDUSTRIAL CHEMISTRY—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

MEDICAL ENTOMOLOGIST (with a degree in entomology and post-graduate experience in problems of sandfly (culicoides) and in work on mosquitoes) with the Government of Jamaica, to carry out investigations relating to the identification and bionomics of Jamaican culicoides and the study of biting mosquitoes, to advise on control methods, and conduct research—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.117/32/025.

POSTDOCTORATE FELLOW, for work in the field of enzyme kinetics, with particular reference to chymotrypsin and cholinesterase; and a RESEARCH ASSISTANT, for work in chemical kinetics leading to the Ph.D. degree—Prof. K. J. Laidler, Department of Chemistry, University of Ottawa, Ottawa 2, Canada.

RESEARCH ASSISTANT (preferably with a higher degree), for chemical and crystallographic study of ferro-magnetic oxide materials—Dr. A. J. E. Welch, Chemistry Department, Imperial College, London, S.W.7.

SCIENTIFIC OFFICER (PHYSICIST) (with a first- or second-class honours degree or equivalent) AT THE BUILDING RESEARCH STATION (D.S.I.R.), Garston, Watford, Herts, for basic research in heat-transfer/aerodynamic/convection processes occurring in heating and ventilation of buildings—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.139/8A.

SCIENTIFIC OFFICER (with an honours degree in metallurgy)—The Chief Clerk, Royal Mint, London, E.C.3.

SENIOR and JUNIOR RESEARCH FELLOWS (normally with a first- or second-class honours degree and evidence of a very high standard of ability in research) in Government Scientific Establishments—The Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S.4798/58.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The Registrar General's Statistical Review of England and Wales for the year 1956. Part 2: Tables, Civil. Pp. x+180. (London: H.M. Stationery Office, 1957.) 7*s.* 6*d.* net. [242

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 21, No. 6: The Bear Island Cod—Migrations and Movements. By C. G. Trout. Pp. iii+51+6 plates. (London: H.M. Stationery Office, 1957.) 16*s.* net. [242

Hunting is No Deer Control. (Reply to the B.F.S.S. pamphlet "No Hunting—No Deer".) Pp. 4. (London: The National Society for the Abolition of Cruel Sports, 1958.) [242

Positive Employment Policies: Examples of Management Practice contributing to Good Relations in Industry. Prepared by the Ministry of Labour and National Service and the Central Office of Information. Pp. 40. (London: Ministry of Labour and National Service, 1958.) [242

Privy Council. Medical Research Council Memorandum, No. 35: The National Collection of Type Cultures—Catalogue of Species. Pp. iii+34. (London: H.M. Stationery Office, 1958.) 2*s.* 6*d.* net. [242

Guide to the Manchester Museum. (Museum Publications, New Series, 1.) Pp. 20+4 plates. (Manchester: The Museum, The University, 1957.) 1*s.* [242

Aero Research Technical Notes. Bulletin No. 181 (January, 1958): Structures Laboratory: an Account of Methods and Apparatus used by Aero Research Limited. Pp. 10. (Duxford: Aero Research Ltd., 1958.) [242

Ministry of Power. Reports of H.M. Inspectors of Mines under the Coal Mines Act, 1911, for 1956. North Eastern Division. By C. W. Scott. Pp. ii+38+6 plates. (London: H.M. Stationery Office, 1958.) 2*s.* 6*d.* net. [242

University of London. London School of Hygiene and Tropical Medicine, incorporating the Ross Institute. Report on the work of the School for the year 1956–1957. Pp. 134. (London: London School of Hygiene and Tropical Medicine, 1958.) [242

Imperial College of Science and Technology (University of London). Fiftieth Annual Report, Jubilee Year, 1956–1957. Pp. 91. (London: Imperial College of Science and Technology (University of London), 1958.) [242

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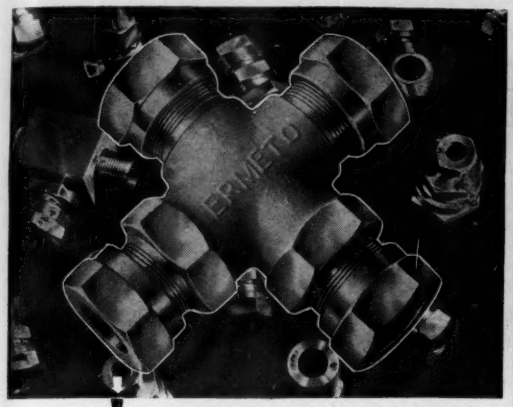

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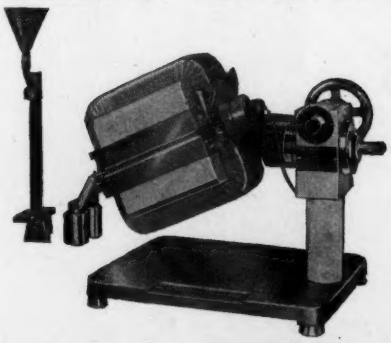

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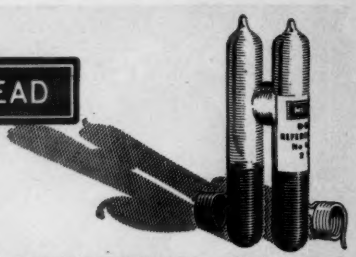

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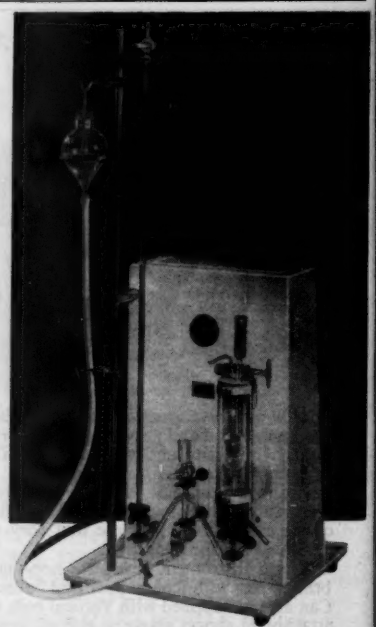

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